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IMPROVEMENTS.—Removing obstructions in Arkansas River, 1673; Arkansas River, 1676; Fourche Le Fevre River, Ark., 1681; Petit Jean River, Ark., 1682; White River, Ark., 1683; Cache River, Ark., 1637; Little Red River, Ark., 1687; Black River, Ark. and Mo., 1689; Black River, Mo., 1691; St. Francis River, Ark., 1693; St. Francis River, Mo., 1694; Little River, Mo., 1696.
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APPENDIX Y.

REPORT OF MAJ. A. MACKENZIE, CORPS OF ENGINEERS.

IMPROVEMENTS.—Operating snag boats and dredge boats on Upper Mississippi River, 1749; Mississippi River, between Des Moines Rapids and mouth of Illinois River, 1766; Des Moines Rapids, Mississippi River, 1772; operating and care of Des Moines Rapids Canal and dry dock, 1773; Mississippi River between Minneapolis and Des Moines Rapids, 1779.

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REPORT OF MAJ. W. A. JONES, CORPS OF ENGINEERS.

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APPENDIX A A.

REPORT OF CAPT. CHAS. F. POWELL, CORPS OF ENGINEERS.

IMPROVEMENTS.—Missouri River between the Great Falls, Mont., and Sioux City, Iowa, 1875; Yellowstone River, Mont. and N. Dak., 1903.
EXAMINATION AND SURVEY.—Missouri River, Mont., between Great Falls and cañon next below Stubbs Ferry, 1904.

APPENDIX B B.

REPORT OF LIEUT. COL. HENRY M. ROBERT, CORPS OF ENGINEERS.

IMPROVEMENTS.—Tennessee River, above Chattanooga, Tenn., and below Bee Tree Shoals, Ala., 1911; Hiawassee River, Tenn., 1920; French Broad River, Tenn., 1922; Clinch River, Tenn., 1925; Cumberland River, Tenn. and Ky., 1927; Caney Fork River, Tenn., 1941; South Fork of Cumberland River, Ky., 1943.

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REPORT OF CAPT. GEO. W. GOETHALS, CORPS OF ENGINEERS.

IMPROVEMENTS.—Tennessee River between Chattanooga, Tenn., and foot of Bee Tree Shoals, Ala., 1945; operating and care of Muscle Shoals Canal, Tennessee River, 1956.

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APPENDIX D D.

REPORT OF MAJ. AMOS STICKNEY, CORPS OF ENGINEERS.

IMPROVEMENTS.—Ohio River, 1960; operating snag boats on Ohio River, 1978; operating and care of Davis Island Dam, Ohio River, 1980; movable dam in Ohio River below mouth of Beaver River, Pa., 1983; Monongahela River, W. Va. and Pa., 1984; operating and care of Locks and Dams Nos. 8 and 9, Monongahela River, 1986; purchase of Lock and Dam No. 7, Monongahela River, 1989; purchase of Lock and Dam No. 6, Monongahela River, 1990; Cheat River, W. Va., 1991; Allegheny River, Pa., 1992; dam at Herr Island, Allegheny River, Pa., 1996; ice harbor at mouth of Muskingum River, Ohio, 1997; operating and care of ice-harbor lock at mouth of Muskingum River, Ohio, 1998; Muskingum River, Ohio, 1999; operating and care of locks and dams on Muskingum River, Ohio, 2000.

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APPENDIX G G.

REPORT OF MAJ. D. W. LOCKWOOD, CORPS OF ENGINEERS.

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CHAS. R. SUTER, Lieutenant-Colonel, Corps of Engineers, U. S. A., President; A. MACKENZIE, Major, Corps of Engineers, U. S. A.; O. H. ERNST, Major, Corps of Engineers, Colonel, U. S. A.; GARLAND C. BROADHEAD and R. S. BERLIN, *Commissioners.*

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY

(CONTINUED.)

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APPENDIX D D.

IMPROVEMENT OF OHIO, MONONGAHELA, CHEAT, ALLEGHENY, AND MUSKINGUM RIVERS.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Ohio River.
2. Operating snag boats on Ohio River.
3. Operating and care of Davis Island Dam, Ohio River, near Pittsburg, Pennsylvania.
4. Movable dam in Ohio River below mouth of Beaver River, Pennsylvania.
5. Monongahela River, West Virginia and Pennsylvania.
6. Operating and care of Locks and Dams Nos. 8 and 9, Monongahela River.
7. Purchase of Lock and Dam No. 7, Monongahela River.
8. Purchase of Lock and Dam No. 6, Monongahela River.
9. Cheat River, West Virginia.
10. Allegheny River, Pennsylvania.
11. Dam at Herr Island, Allegheny River, near Pittsburg, Pennsylvania.
12. Ice harbor at mouth of Muskingum River, Ohio.
13. Operating and care of ice-harbor lock at mouth of Muskingum River, Ohio.
14. Muskingum River, Ohio.
15. Operating and care of locks and dams on Muskingum River, Ohio.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 16, 1892.

GENERAL: I have the honor to transmit herewith the annual reports on the works under my charge for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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D D 1.

IMPROVEMENT OF OHIO RIVER.

Statement of amounts and date of all appropriations for this work.

Act of Congress.	Appropriations.	Allotments.	Remarks.
Mar. 3, 1827	$30,000.00	.....	
Mar. 3, 1835	50,000.00	.....	
July 2, 1836	20,000.00	.....	
Mar. 3, 1837	60,000.00	.....	
July 7, 1838	50,000.00	.....	
June 11, 1844	100,000.00	.....	
Mar. 3, 1847	6,479.25	.....	
Aug. 30, 1852	90,000.00	.....	
June 23, 1866	.....	$172,000.00	Improving Mississippi, Missouri, Arkanhas, and Ohio rivers.
Do.....	.....	80,000.00	Snag boats and apparatus for improving Western rivers.
Mar. 2, 1867	100,000.00	.....	
July 25, 1868	.....	85,000.00	Repair, preservation, extension, and completion of river and harbor works.
July 11, 1870	50,000.00	.....	
Mar. 3, 1871	50,000.00	.....	
June 10, 1872	200,000.00	.....	
Mar. 3, 1873	200,000.00	.....	
June 23, 1874	150,000.00	.....	
Mar. 3, 1875	300,000.00	.....	
Aug. 14, 1876	175,000.00	.....	
June 18, 1878	300,000.00	.....	
Do.....	50,000.00	.....	Harbor of refuge at or near Cincinnati.
Mar. 3, 1879	250,000.00	.....	
June 14, 1880	250,000.00	.....	
Mar. 3, 1881	350,000.00	.....	
Mar. 21, 1882	100,000.00	.....	Continuing work on Davis Island Dam.
Aug. 2, 1882	350,000.00	.....	
Do.....	16,000.00	.....	Harbor of refuge near Cincinnati, Ohio.
July 5, 1884	600,000.00	.....	
Do.....	17,000.00	.....	Do.
Aug. 5, 1886	375,000.00	.....	
Aug. 11, 1888	380,000.00	.....	
Sept. 19, 1890	300,000.00	.....	
	4,969,479.25	337,000.00	
Deduct amounts transferred to other works	125,168.48	.....	
	4,844,310.77	337,000.00	

The last appropriation for this river was made in the river and harbor act of September 19, 1890. The amount, $300,000, was allotted to various works as follows, viz:

Ice pier at Kerrs Run, Ohio	$7,500
Ice pier at Portsmouth, Ohio	7,500
Ice pier at Ripley, Ohio	7,500
Madison Harbor	20,000
Great Miami embankment	13,250
Shawneetown embankment	15,000
Rock bar at mouth of Licking River	20,000
Dike at foot of Marietta Island	7,100
Dam at head of Blennerhassett Island	33,010
Dike at Cullums Bar	29,840
Dike at Rising Sun	23,300
Dike at Flint Island	40,060
Service of United States dredges, two years; contingencies, engineering, and office expenses, two years	75,940
Total	300,000

At the beginning of the fiscal year, July 1, 1891, there remained $138 [illegible] of this appropriation, which has been applied to the works

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for which allotted, and various incidental expenses which were not contemplated at the time the allotments were made.

The following works were in progress during the year:

Dam between Davis and Neville islands, 5 miles below Pittsburg.—At the beginning of the fiscal year some minor repairs, consisting of repaving and grouting the slopes of the dam, were being made. These repairs were completed August 15, 1891.

Dam at Marietta Island, 168 miles below Pittsburg.—This dam was completed in December, 1890. During the winter of 1890–'91 some damage was done to the paving and filling of the downstream slope. At the beginning of the fiscal year this damage was being repaired. The work was done by hired labor and was completed October 21, 1891.

Dike at foot of Marietta Island, 171 miles below Pittsburg.—Under contract dated February 14, 1891, with J. C. Graham. The object of this dike is to hold the water coming down the right-hand chute of Marietta Island and prevent it from spreading until after it has passed the Marietta Wharf. It was originally built in 1844, and was repaired and extended in 1875. It was in good condition, but owing to the increased height given to the dam at the head of the island it was necessary to raise the dike to the same height in order to cut off the cross current. Work was commenced July 6, 1891, and completed October 23, 1891.

Dam at head of Blennerhassett Island, 185 miles below Pittsburg.—Under contract dated February 14, 1891, with Richardson & Monroe. The object of rebuilding this dam (originally constructed in 1844), which had been gradually worn down, was to send more water down the navigable channel on the Ohio side of the island and to improve the bar at the foot. Work was progressing at the beginning of the fiscal year, and the dam was completed December 28, 1891.

Dike at Eight Mile Island, 256 miles below Pittsburg.—Under contract dated February 9, 1889, with John J. Shipman. The object of the dike is to deepen the water on the bar at the foot of Eight Mile Island. Owing to high water the contractor failed to complete the dike within the time specified, and on the recommendation of the officer in charge the contract was extended to December 31, 1891. Work commenced August 15, and the dike was completed November 19, 1891.

Dike at Cullums, 471 miles below Pittsburg.—Under contract dated February 9, 1891, with John J. Shipman. The object of this dike is to straighten and widen the channel by cutting off the narrow and crooked passage down the right-hand shore, and thus compel the river to make a new and more commodious channel across the present bar. Work on the dike was progressing at the beginning of the fiscal year and was completed December 9, 1891.

Dike at lower bar at Rising Sun, 502 miles below Pittsburg.—Under contract dated February 9, 1891, with John J. Shipman. The object of this dike is to improve the lower bar at Rising Sun, which, since the improvement of the upper bar, has been the chief sticking place between Cincinnati and Louisville. Work on this dike was progressing at the beginning of the fiscal year and was completed November 25, 1891.

Dike at Madison, Indiana, 552 miles below Pittsburg.—Under contracts dated February 9, 1889, and February 14, 1891, with William Kirk. The construction of this dike was ordered by Congress, and its object is to improve the harbor of Madison by deepening the water on the flat shore bar that lies along the whole front of the city. Work on this dike was progressing at the beginning of the fiscal year and continued

until November 22, 1891, when the contractor was compelled to abandon the work on account of high water. The dike was almost completed; only a little paving remains to be done.

On the recommendation of the officer in charge this contract was extended to November 30, 1892.

Dike at Flint Island, 683 miles below Pittsburg.—Under contract dated February 14, 1891, with William Kirk. The object of this dike is to contract the river and thus deepen the water below Flint Island, there being two channels at this place, neither of which is deep enough for navigation during the low-water season. At the beginning of the fiscal year work on this dike was progressing, and on November 25, 1891, it was completed.

Dike at middle of Grand Chain, 946 miles below Pittsburg.—Under contract dated December 1, 1884, with I. V. Hoag, jr. The channel at the Grand Chain is bordered on the right by reefs of rock along a length of about 6 miles, extending in some places to the middle of the river. The object of building dikes at this locality is to force the channel away from these rocks. One dike has been built at the head of the Chain and another at the foot, the dike now under construction being intermediate. It is the most unfavorable location for work on the Ohio River, as it is only 20 miles from the Mississippi, and flood stages in the latter river stop work at the Grand Chain almost as effectually as floods in the Ohio. This accounts for the slow progress of the work, and the long time that has elapsed since the contract was let. At the beginning of the fiscal year the dike was about two-thirds completed. Work was resumed on September 28 and continued until November 28, when operations were stopped by high water. The entire length of this dike is 3,008 feet, and there remains unfinished about 10 per cent of the work. On the recommendation of the officer in charge the time for completion of contract has been again extended to December 31, 1892.

ROCK EXCAVATION.

Rock bar at mouth of Licking River, 466 miles below Pittsburg.—This bar consists of limestone rock *in situ*, covered in part by loose rock and gravel. The total area of this bar is about 48 acres, and it projects toward the Ohio shore more than half the low-water width of the river, leaving a narrow but comparatively deep channel on the Ohio side. At low water this bar completely shuts off all navigation between the Ohio and Licking rivers. Through this bar it was proposed to cut a channel about 1,500 feet long and 200 feet wide with a minimum depth of 4 feet at low water. Work began in 1887 at the south limit of the bar, and a channel 65 feet wide and 135 feet long was cut. This exhausted the limited sum available, $18,750. By the river and harbor act of August 11, 1888, $25,000 was allotted for this work and an additional allotment of $20,000 was made by the act of September 19, 1890. A contract for continuing this work was made July 12, 1889, with J. F. King, but after waiting two seasons for low water he abandoned the work and his contract was annulled. Authority was granted to do the work by hired labor, and at the beginning of the fiscal year material and plant were on the ground. Work was commenced on July 6, 1891, and continued whenever the water would permit until November 15, 1891, when all the work projected for the season had been completed. The cut made was through the highest part of the bar and is now about 475 feet long. The total quantity of solid stone removed was 2,235 cubic yards. This work was done under the supervision of Mr. I. V. Hoag, jr., assistant engineer.

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ICE PIERS.

Ice piers are high isolated cribs filled with stone, placed at the upper end of a landing in order to ward off ice and drift. An ice pier is usually built in two or more sections, with an interval between them somewhat greater than the width of a section, the lines of sections being at right angles to the shore or inclining downstream. As built on the Ohio River, ice-pier sections have a base of 24 by 44 feet and a top of 24 by 17. The outermost section is usually built to a height of 30 feet above low water and the inner sections a few feet higher.

The acts of Congress authorizing the construction of ice piers require an antecedent cession of riparian rights in favor of water craft seeking shelter from ice.

Ice pier at Kerrs Run, 247 miles below Pittsburg.—Under contract dated May 23, 1891, with James R. Ware. This ice pier is located at the upper end of the city of Pomeroy, Ohio. Work commenced November 2, 1891, and was continued until February 16, 1892, when the stage of water prevented any further work. Only about 40 per cent of the work was done. On the recommendation of the officer in charge the time for completing this contract was extended to June 1, 1892, and again extended to September 1, 1892.

Ice pier at Portsmouth, 353 miles below Pittsburg.—Three sections of this ice pier were completed during the fiscal year ending June 30, 1891. The fourth section under contract dated May 23, 1891, with James R. Ware, was commenced July 16 and completed December 4, 1891.

Ice pier at Ripley, 414 miles below Pittsburg.—Under contract dated May 23, 1891, with James R. Ware. Work commenced July 6, completed November 1, 1891.

EMBANKMENTS.

Great Miami embankment, 489 miles below Pittsburg.—The river and harbor acts of 1886 and 1888 state that the object of this work is to confine the waters of the Great Miami River in great floods, "to the end that the formation of the bar in the Ohio River, now forming and obstructing navigation, may be arrested." The extension of this embankment under contract dated June 10, 1891, with John Johnson, commenced July 8, and the work provided for by this contract was fully completed by November 28, 1891; the total of material put in place was 33,435.1 cubic yards. By authority of the Chief of Engineers, dated November 17, 1891, arrangements were made with the Cleveland, Cincinnati, Chicago, and St. Louis Railway Company for a further extension of this embankment to the limit of available funds. Under this arrangement, 19,640 cubic yards of material was put in place by March 31, 1892, and, as the available funds were exhausted, the work ceased.

Embankment at Shawneetown, 848 miles below Pittsburg.—The object of this work is stated in the river and harbor act to be "the preservation of the harbor," and the work to be done is to strengthen the existing levee by additional earth and to protect the exposed faces by riprap or paving. At the beginning of the fiscal year the only portion of the projected work remaining to be done was the protection of the exposed faces of the levee by riprap and paving. A contract for this work was made under date of September 23, 1891, with James Short, at prices less than the estimate, and the work was completed on the 5th of April, 1892. The balance of the funds available for this work will probably be applied to raising and strengthening the levee still further at weak points.

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BIG HOCKING RIVER.

This river enters the Ohio at a point 197 miles below Pittsburg and 14 miles below Parkersburg. The work of improving navigation on this stream is paid for out of the appropriation for the improvement of the Ohio River, and it therefore appears under that heading. The object to be attained is to permit Ohio River steamboats to ascend to Coolville, 5 miles above the mouth, during high and medium stages of the Ohio, taking advantage of the backwater.

This work was under the immediate supervision of Lieut. Cassius E. Gillette, Corps of Engineers, U. S. Army, until April 12, 1892. Since that time Mr. Edmund Moeser, assistant engineer, has had immediate supervision of the work.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM REPORT OF MR. EDMUND MOESER.)

The work of improving navigation on this stream between its mouth and Coolville, 5 miles above, by removing rocks and snags from the channel, was continued during the months of July and August and closed September 1, 1891, as everything had been done for which there was any necessity.

The following is a summary of the work done:

Stone removed	cubic yards	627
Logs removed	number	48
Drift piles removed	do	1
Fallen trees trimmed	do	2

WORK OF OHIO RIVER DREDGES DURING THE CALENDAR YEAR OF 1891.

This work has been under the immediate charge of Mr. E. J. Carpenter, assistant engineer.

OPERATIONS.

(EXTRACT FROM REPORT OF MR. E. J. CARPENTER.)

The dredges remained in winter quarters at the mouth of the Muskingum River until March 6, 1891, when the *Oswego* was sent to the Monongahela River to work at Locks No. 8 and No. 9. She remained there until April 5, when she returned to Pittsburg and was laid up, until joined by the *Ohio* and the rest of the fleet for the annual repairs, on April 17.

Owing to the late date at which the appropriation for 1890 became available, only such repairs had been made as were absolutely indispensable to fit the boats for temporary service. The repairs for the season of 1891 were therefore extraordinarily large, including the following unusual items, viz:

For the *Ohio*, three new steel spuds; new tin roof for the cabin; new and larger crank shaft with fittings for the main engines; a change from positive to friction clutch for hoisting the aft spud; improved gearing for hoisting the forward spuds by hand, and new packing for the capstan engines.

For the *Oswego*, a new steel dipper pole; new crank shaft and fittings for the main engines; new packing for the main engines and capstan engines; friction clutch for aftspud hoist; improved gearing for hoisting the forward spuds by hand; a complete set of new chains, and an iron roof over the whole of the boat.

During the repairs three towboats were burned at the Pittsburg wharf, two of them alongside the *Oswego*, burning her sides and roof so badly as to necessitate considerable expenditure to restore them. The destruction of one dredge, and possibly of both, by the fire was avoided only by prompt and intelligent action of the engineer, Mr. A. C. Siewers.

The purchase of tools, a pipe and bolt-fitting machine, a metal shaper, an emery grinder, a large drill press, and a 6-inch by 6-inch vertical engine added to the cost for equipment, but probably did not much increase the total expenditure for the season, because work done by them reduced machine shop bills by an amount almost equal to their cost.

The dump scows built in 1881 were worn out and so rotten that they could not be repaired. They were therefore condemned, and plans were prepared from which two new scows were built at a cost of $3,768.59 each, $3,537 being the price paid the

contractors, S. W. Coflin & Son, and $231.59 the cost of materials for the trusses, which, to save delay, were purchased and furnished to the contractors. The scow designs embodied some new features, the principal being a pair of vertical steel trusses extending full length in the hold of each scow to distribute the load in the bins and thus prevent the hull from bending.

The trusses have answered the purpose perfectly, the scows being in excellent condition after a season of hard service.

The cost of building the scows is not included in the tabular statement for the year.

Upon completion of the repairs the dredges started down the river; their first work being at the Davis Island Dam.

Davis Island Dam, Pennsylvania, 5½ miles below Pittsburg.—The dredges made two cuts about 200 feet long below the lock, removing the bar at the guiding crib, which obstructed the approach to the lock. Excavation made July 3 to 13: shale, gravel, etc., 2,362 cubic yards.

Three Brothers Islands, 160 miles below Pittsburg.—July 16 the dredges pulled out of the channel a sunken coal flat, which the owners afterwards raised and removed.

Marietta Dike, 171 miles below Pittsburg.—After the dam across the West Virginia channel at the head of Marietta Island was rebuilt, it was found that the increased volume of water on the Ohio side caused a dangerous cross current over the lower end of the riprap dike at the foot of the island, particularly during a rise of the Muskingum. About 500 feet of the lower end of the old dike was therefore removed by the dredges, which at the same time dug off a part of the gravel bar at the dike. Excavation made July 17 to 24 and July 27 to 30: loose rock, 4808 cubic yards, gravel, 7,212.3 cubic yards. The dredges also removed 171 piles, 1 coal-boat wreck, and 10 logs and snags weighing 26.1 tons.

Marietta, Ohio, 170¼ miles below Pittsburg.—During a rise of the river, which stopped operations at Marietta Dike, the dredges were employed to remove the shore bar at the railroad incline just above the Fourth Street Wharf at Marietta. Material dredged from this bar was dumped at the foot of the island to stop leaks at the new dike, then in process of construction. Excavation made July 25 to 29: hard clay and gravel, 3,393 cubic yards.

Head of Blennerhassett Island, 185 miles below Pittsburg.—July 30 the dredges stoppped while traveling to tear up and remove from the channel one wreck of coal barge.

Foot of Blennerhassett Island, 188¼ miles below Pittsburg.—A bar consisting of pudding stone and hard gravel, on the Ohio shore above the location of the old dike, was dredged off. The removal of this bar, which deflected the current toward the tow-head below the island, has materially facilitated the passage of tows in both directions, and by permitting the current to follow the axis of the river will tend to keep open a good low-water channel. Excavation made July 31 to August 20: pudding stone, 5,703 cubic yards; hard gravel, 17,107 cubic yards. There was also removed from the channel 1 snag weighing 3.1 tons.

Foot of Blennerhassett Island, 188¾ miles below Pittsburg.—The dredges completed the removal of the old dike on the Ohio shore, on which they had been previously employed in 1889 and 1890, until stopped by high water. Excavation made July 31 to August 3: loose rock 1851.0 cubic yards.

Swan Bar, 212¼ miles below Pittsburg.—While traveling the dredges removed from the channel at this place, August 20, 1 snag weighing 12 tons.

Siegrists Ripple, 240¼ miles below Pittsburg.—A wrecked coal barge was broken up and removed from the channel at this place August 21.

Little Indian Creek, above New Richmond, Ohio, 445¼ miles below Pittsburg.—During high water, which prevented the dredges from working at Nine Mile Bar, they removed the creek bar at this point, which had been dredged off in 1880, but had again built out into the river. The work straightened the channel and widened it 145 feet. Excavation made August 25 to September 16: gravel, etc., 16,119.1 cubic yards; wreck removed, 1 coal flat; snag removed, 1, weighing 2.5 tons.

Nine Mile Creek Bar, 451¼ miles below Pittsburg.—Ninemile and Tenmile creeks, on the Ohio side, come together a short distance from the river, and formerly ran parallel to the latter for several hundred yards above their mouth. During the past year, however, they have cut through the bank and now empty into the river about 1,200 feet above the old mouth. At this point there is a shore bar, composed of pudding stone, which deflects the river current and causes the low-water channel to turn from the Ohio, or concave side, to the Kentucky shore, where, as it runs through light sand and gravel, it becomes filled up by the higher stages. The existence of a pocket of deep water on the Ohio side behind the main Ninemile Bar shows that the channel naturally inclines to this side of the river, and indicates that if the obstructions which deflect the current were removed, the channel would maintain itself on this shore. A part of the pudding-stone bar was broken up by blasting it with dynamite, and was then dredged off, widening the channel 125 feet. A large amount of deposit from the creek was removed at the same time. The material removed was dumped on the opposite side of the river, where it serves to turn the current more strongly into the proposed new channel. Sufficient work has been done to make a material

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change in the current, causing it to follow more nearly the line of the Ohio shore, but additional dredging will no doubt be necessary to complete the improvement. The dredges removed a number of logs from the channel. Excavation made October 1 to November 6: pudding stone, 8,508 cubic yards; gravel, etc., 19,851.4 cubic yards; snags and logs removed, 11, weighing 9 tons.

Head of Ninemile Bar, 452 miles below Pittsburg.—A cut about 40 feet wide, extending 3 feet below channel depth, was made from the deep water below the creek bar to the pocket near the Ohio shore, a distance of about 1,600 feet. Most of the material, which consisted of sand and gravel, was dumped on the Kentucky shore above. No large rocks or logs were found in this bar, which, however, proved to be exceedingly hard and compact. The object of the dredging was to break the surface of the bar on the line of the proposed new channel, and thus lead the river current to cut the bar away in the desired direction. Excavation made September 17 to October 5; sand and gravel, 12,237.5 cubic yards.

Eightmile Bar, 453 miles below Pittsburg.—During the low-water season the channel at this point was filled up by light sand, and as the dredges were within easy reach, one of them was employed to open up a channel by cutting through the sand reef. The first cut soon filled up, but a second was made, which sufficed for the small boats running until the river rose. Excavation made September 29 to October 1, and October 6 to 9: soft sand, 5,291 cubic yards.

Cullums Ripple, 471½ miles below Pittsburg.—The construction of the new dike at Cullums, by changing the current to the Kentucky side of the river, where it made a channel through the gravel bar, exposed a number of obstructions, most of which were removed by the snag boat *Woodruff*. The most serious one however, the wrecked hull of the large steamboat *Mollie Ebert*, was left for the dredges, which removed it after considerable difficulty. Excavation made November 11 to November 12: 273 cubic yards; wreck removed November 11 to November 15: 1 steamboat hull.

Upon completion of the wrecking at Cullums the dredges removed the cofferdam in Licking River, after which they left for the mouth of the Kentucky River, where they were laid up for the winter.

Owing to lack of money no dredging has been done in 1892, the boats remaining in the Kentucky River.

Ohio River dredging statement for 1891.

DREDGES IN COMMISSION.

	Time at work.		Time lost.
	Days.		*Days.*
Dredging gravel, sand, etc	55½	Traveling	8
Dredging loose rock, pudding stone, etc	27	Accidents	12
Removing logs and snags	3	High water	6
Removing wrecks	4½	Sundays	20
		Working in Licking River	6
Total days at work	90	Total days lost, etc	*52

* Total days in commission, 142.

WORK.

Gravel, sand, etc., excavated per day of work	cubic yards	1,469.6
Gravel, sand, etc., excavated during the season	do	81,564.3
Loose rock, pudding stone, etc., excavated per day of work	do	860.5
Loose rock, pudding stone, etc., excavated during the season	do	23,232.0
Total excavation during the season	do	104,796.3
Logs and snags removed (twenty-four)	tons	57.2
Wrecks removed		6
Piles pulled out		171

COST.

Equipment:		Repairs—Continued.	
Per day in commission	$12.81	For the season	$1,087.32
Per day of work	20.21	Salaries:	
For the season	1,819.85	Per day in commission	41.94
Towing and fuel:		Per day of work	66.18
Per day in commission	39.50	For the season	5,956.14
Per day of work	62.33	Total cost:	
For the season	5,608.97	Per day in commission	101.91
Repairs:		Per day of work	160.80
Per day in commission	7.66	For the season	14,472.28
Per day of work	12.08		

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DREDGES OUT OF COMMISSION.

Time—	Days.
In ordinary	143
Annual repairs	80
Total	223

COST.

Salaries in ordinary	$2,036.48	
Towing, etc	120.00	
Total in ordinary		$2,156.48
Salaries during annual repairs	5,002.86	
Annual repairs (shop bills, materials, etc.)	4,639.78	
Total cost of repairs		9,642.64
Total out of commission		11,799.12
Cost per day in ordinary (including superintendent's pay)		15.08

COST OF WORK, INCLUDING ALL EXPENDITURES IN 1891.

Dredging gravel, sand, etc	$15,324.99
Dredging loose rock, pudding stone, etc	8,757.13
Removing logs, piles, and snags	875.71
Removing wrecks	1,313.57
Total expenditures in 1891	26,271.40

COST PER UNIT.

Per cubic yard of gravel, etc., excavated	$0.188
Per cubic yard of loose rock and pudding stone	.377
Per day in commission	101.92
Per day of work	291.90

Location and description of work.

Place.	Miles below Pittsburg.	Date, 1891.	Days of work.	Snags and logs removed.	Tons weight.	Piles removed.	Wrecks removed.
Davis Island Lock at lower guiding crib	5½	July	3				
Three Brothers Islands	160	....do	¼				1
Dike at foot of Marietta Island	171	....do	4½				
Do	171	....do	4½				
Do	171	....do	1¾	10	26.1	171	1
Marietta (Ohio) Bar, outside of Fourth Street Landing.	170¾	....do	2				
Head of Blennerhassett Island	185	....do	½				1
Foot of Blennerhassett Island:							
Old dike on Ohio shore	188¾	July-Aug	2½				
Bar on Ohio shore, above old dike	188¼	....do	10	1	3.1		
Do	188¼	....do	8				
Swan Bar	212½	August	¼	1	12		
Siegrist Ripple	240½	....do	1				1
Little Indian Creek Bar (New Richmond, Ohio)	445½	Aug.-Sept	13				
Do	445½	....do	1	1	2.5		1
Nine-Mile Bar, at head	451½	Sept.-Oct	¾	11	9		
Nine-Mile Bar (Ohio) Chute, at head	452	....do	10				
Nine-Mile (Ohio) Creek Bar	451½	Oct.-Nov	12				
Do	451½	....do	10				
Eight-Mile Bar	453	Sept.-Oct	3				
Cullum Bar	471½	November	2				1
Total			90	24	52.7	171	6

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Place.	Kind of material removed.	Excavation.			
		Gravel, etc.	Loose rock, pudding stone, etc.	Per day of work.	Cost per cubic yard.
		Cu. yds.	*Cu. yds.*	*Cu. yds.*	
Davis Island Lock, at lower guiding crib.	Shale, gravel, etc		2,362	787.5	$0.37
Three Brothers Islands	Wreck, coal flat				
Dike at foot of Marietta Island	Loose rock		4,808	1,068.5	.273
Do	Gravel	7,212.3		1,602.7	.182
Do	Wrecks, snags, piles, etc.				
Marietta (Ohio) Bar, outside of Fourth Street Landing.	Hard clay and gravel	3,393		1,696.5	.172
Head of Blennerhassett Island	Wreck, coal barge				
Foot of Blennerhassett Island:					
Old dike on Ohio shore	Loose rock		1,851	740.4	.394
Bar on Ohio shore, above old dike.	Hard gravel	17,107		1,710.7	.171
Do	Pudding stone		5,703	712.9	.409
Swan Bar	Snag				
Siegrist Ripple	Wreck, coal barge				
Little Indian Creek Bar (New Richmond, Ohio).	Gravel, etc	16,199.1		1,246.1	.234
Do	Wreck and snags				
Nine-Mile Bar, at head	Snags, logs, etc				
Nine-Mile Bar (Ohio) Chute, at head.	Hard sand and gravel	12,237.5		1,223.8	.238
Nine-Mile (Ohio) Creek Bar	Pudding stone		8,508	709	.412
Do	Gravel, etc	19,851.4		1,985.1	.147
Eight-Mile Bar	Soft sand	5,291		1,763.7	.127
Cullum Bar	Wreck, steamboat hull	273			
Total		81,564.3	23,232		

Place.	Expenditures.			
	For dredging gravel, etc.	For dredging pudding stone, loose rock, etc.	For removing wrecks, logs, and snags.	Total for 1891.
Davis Island Lock, at lower guiding crib		$875.71		$875.71
Three Brothers Islands			$72.98	72.98
Dike at foot of Marietta Island		1,313.57		1,313.57
Do	$1,313.57			1,313.57
Do			510.83	510.83
Marietta (Ohio) Bar, outside of Fourth Street Landing.	583.81			583.81
Head of Blennerhassett Island			145.95	145.95
Foot of Blennerhassett Island:				
Old dike on Ohio shore		729.76		729.76
Bar on Ohio shore, above old dike	2,919.04			2,919.04
Do		2,335.24		2,335.24
Swan Bar			72.98	72.98
Siegrist Ripple			291.90	291.90
Little Indian Creek Bar (New Richmond, Ohio)	3,794.76			3,794.76
Do			291.90	291.90
Nine-Mile Bar, at head			218.93	218.93
Nine-Mile Bar (Ohio) Chute, at head	2,919.05			2,919.05
Nine-Mile (Ohio) Creek Bar		3,502.85		3,502.85
Do	2,919.05			2,919.05
Eight-Mile Bar	875.71			875.71
Cullum Bar			583.81	583.81
Total	15,324.99	8,757.13	2,189.28	26,271.40

REMOVAL OF ROCK AND OTHER OBSTRUCTIONS.

In October a small party was put to work removing dangerous obstructions along the channel between Pittsburg and Steubenville, Ohio. The lateness of the season prevented a thorough cleaning of the channel, such as should have been made, yet, nevertheless, good was accomplished at several places. The following is a list of the obstructions removed and the localities:

Deadman Island, 200 cubic yards of rock.
Montgomery Island, 12 cubic yards of rock.

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Phillis Island, 40 cubic yards of rock.
Line Island, 80 cubic yards of rock and some snags.
Babbs Island, wreck of coal boat.

ENCROACHMENTS.

At many places along the banks of the river where navigators had complained of encroachments, examinations were made, and many parties were stopped from depositing waste material in the river.

One firm, who have been engaged in the business of digging sand from the bed of the river, have been in the habit of leaving huge piles of gravel, the refuse of their digging operations, lying in the channel in the vicinity of Brunot Island. In November their operations became so dangerous to navigation that it was necessary to have the parties prosecuted. When the case came to trial the members of the sand company pleaded guilty. The court imposed a fine of $50 each, and the costs, on the principals, and suspended sentence in the case of the employés.

Information has been received at various times that certain parties along the Ohio River were dumping material into the river or over its banks. Investigations have been made, and wherever the dumping or filling into the river interfered with navigation, or was an encroachment on the channel of the river, the matter has been reported to the United States district attorney for his action.

HARBOR LINES.

Under the provisions of section 12 of the river and harbor act of September 19, 1890, three boards of engineer officers were convened by the Chief of Engineers, under the authority of the Secretary of War, to consider and report upon the subject of harbor lines at Pittsburg, Pa., Wheeling, W. Va., and Cincinnati, Ohio. These boards had meetings and recommended the making of careful surveys and maps of the three vicinities, and the officer in charge of the Ohio River improvement received instructions to have the work done and paid for from the appropriation for the Ohio River. The field work has been finished and a large part of the work on the maps, but this latter work was suspended on account of the lack of funds for completion.

BRIDGES OVER THE OHIO RIVER.

During the past fiscal year this office has had supervision of the erection of the following bridges, viz:

Bridge of Wheeling Bridge Company, at Wheeling, W. Va., 90 miles below Pittsburg. This bridge was completed in October, 1891, in full accordance with the plans approved by the Secretary of War.

Bridge of West Virginia and Ironton Railroad Company, at Kenova, W. Va., 313 miles below Pittsburg. It is believed that this bridge has been completed within the last few days, but this office has not yet been notified of its completion by the builders of the bridge.

Bridge of the Central Bridge Company, between Newport and Cincinnati, 466 miles below Pittsburg. This bridge was completed in September, 1891, in full accordance with the plans approved by the Secretary of War.

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STAGES OF THE OHIO RIVER DURING 1891-'92.

The following are the records of the gauges at Pittsburg, Cincinnati, and Evansville, which may be taken to represent the navigable condition of the Upper, Middle, and Lower Ohio.

Gauge of Davis Island Dam, near Pittsburg.—When the dam is up, low-water readings must be obtained from the gauge at the lower end of the lock. On this gauge 3 feet 2 inches corresponds to a navigable depth of 3 feet, and 6 feet corresponds to the same depth in the river.

Davis Island Dam.	Depth in channel.			Gauge readings.	
	Under 3 feet.	3 feet and over.	6 feet and over.	Highest.	Lowest.
1891.	*Days.*	*Days.*	*Days.*	*Feet.*	*Feet.*
July	0	31	13	11.9	4.0
August	0	31	12	10.7	3.7
September	10	20	4	6.8	1.9
October	25	6	0	3.8	1.9
November	12	18	7	12.8	2.4
December	0	31	29	15.10	5.7
1892.					
January	0	31	22	21.4	4.6
February	0	29	27	13.1	5.1
March	0	31	29	14.9	5.6
April	0	30	30	12.7	6.0
May	0	31	29	12.7	5.5
June	0	30	22	15.3	4.9
Total	47	319	224	.....	.....

Cincinnati gauge.—The zero of this gauge is about 2 feet below low water; readings of about 4 feet correspond to about 3 feet in the channel, and those of 7 feet to about 6 feet in the channel.

Cincinnati.	Depth in channel.			Gauge readings.	
	Under 3 feet.	3 feet and over.	6 feet and over.	Highest.	Lowest.
1891.	*Days.*	*Days.*	*Days.*	*Feet.*	*Feet.*
July	0	31	31	18.2	9.7
August	0	31	31	20.1	8.1
September	0	30	22	17.8	5.5
October	0	31	0	6.2	4.5
November	0	30	13	24.6	4.5
December	0	31	31	27.2	12.4
1892.					
January	0	31	31	41.6	14.0
February	0	29	29	29.6	13.9
March	0	31	31	34.5	17.0
April	0	30	30	43.8	20.5
May	0	31	31	32.2	17.2
June	0	30	30	31.8	15.0
Total	0	366	310	.....	.....

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Evansville gauge.—The zero of this gauge is at the low-water line. Readings of 2 feet correspond to about 3 feet in the channel, and readings of 6 feet correspond to about 6 feet in the channel.

Evansville.	Depth in channel.			Gauge readings.	
	Under 3 feet.	3 feet and over.	6 feet and over.	Highest.	Lowest.
1891.	*Days.*	*Days.*	*Days.*	*Feet.*	*Feet.*
July	0	31	31	16.0	6.8
August	0	31	31	9.4	6.6
September	0	30	21	13.5	3.9
October	0	31	0	3.7	2.1
November	0	30	7	15.9	2.0
December	0	31	31	18.9	9.3
1892.					
January	0	31	31	33.4	12.0
February	0	29	29	25.9	12.9
March	0	31	31	29.8	17.0
April	0	30	30	38.2	20.6
May	0	31	31	34.6	16.0
June	0	30	30	24.1	12.1
Total	.....	366	303	.....	.....

OPERATION OF DRAWS IN HIGH BRIDGES.

There are no low drawbridges on the Ohio River; the general Ohio River bridge law requires that all bridges shall have a height of at least 40 feet above high water, and, since large steamboats require more than 40 feet, it is also provided that all bridges below the Cincinnati Suspension Bridge shall have a draw for use in high water, unless they give a clearance of at least 53 feet above high water. There are three high-water draws on the Ohio River, but the draw in the Ohio Falls Bridge, at Louisville, is exceptionally located, and no record of its operation is kept.

Reports from the two other draws have been received. Owing to the favorable stage of water in the river these draws were not operated during the fiscal year.

STOPPAGE OF NAVIGATION BY ICE.

The past winter was a very mild one, and assuming, as heretofore, that the condition of affairs at Cincinnati is a fair average for the whole river, I have to report that the navigation of the Ohio River was not affected by ice during the past fiscal year.

LOSSES BY COLLISION WITH BRIDGES.

The following tables show the losses sustained by the commerce of the Ohio River during the past fiscal year by collision with the piers of bridges crossing the Ohio River.

KENOVA BRIDGE.*

Date.	Owner.	Steamboat.	Loss:	Amount.
	Previously reported			$8,700.00
Mar. 26, 1892	S. S. Crump & Co	J. C. Risher	4 coal boats	10,000.00
	Total			18,700.00

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* Unfinished.

COVINGTON AND CINCINNATI RAILROAD BRIDGE.*

Date.	Owner.	Steamboat.	Loss.	Amount.
	Previously reported			$43,150.00
May 22, 1892	W. H. Brown Sons	Charles Brown	Barge damaged	150.00
	Total			43,300.00

HENDERSON BRIDGE.†

	Previously reported			$18,480.00
Dec. 7, 1891	W. H. Brown Sons	Alice Brown	1 coal boat	2,040.00
	Total			20,520.00

CAIRO BRIDGE.*

	Previously reported			$9,242.00
Jan. 26, 1892	S. S. Crump & Co	Smoky City	1 coal boat, 1 barge, 1 flat.	4,300.00
Feb. 18, 1892	W. H. Brown Sons	Mariner	1 barge	2,454.65
	Total			15,996.65

Losses by collision with Ohio River bridges to June 30, 1892.

Beaver Bridge	$56,040.00	Covington and Cincinnati railroad Bridge	$43,300.00
Steubenville Bridge	90,308.00	Cincinnati Southern Railroad Bridge	9,812.00
Wheeling and Martins Ferry Bridge	9,800.00	Ohio Falls Bridge	80,350.00
Bellaire Bridge	126,576.00	Kentucky and Indiana Bridge	27,767.00
Parkersburg Bridge	72,677.00	Cairo Bridge	15,996.65
Point Pleasant Bridge	9,600.00	Henderson Bridge	20,520.00
Kenova Bridge	18,700.00		
Newport and Cincinnati Railroad Bridge	44,107.00	Total	625,553.65

ESTIMATE.

The following estimate made by my predecessor, Lieut. Col. William E. Merrill, in his last annual report, of the amount of money that should be appropriated to a river of the magnitude of the Ohio and with so large and valuable a commerce, is repeated:

Low dams and dikes	$600,000
Davis Island Dam	11,500
Rock bar at mouth of Licking River	20,000
Dredging	20,000
Removal of rock reefs in channel	20,000
General administration, inspection, engineering, and contingencies	35,000
Total	706,500

The item of $11,500 inserted for the Davis Island Dam is composed of $3,500 inserted for quarters on Davis Island and $8,000 for extending the guide crib below the land wall of the lock. Experience, after the work was completed, showed that more men were required to manage the lock and dam than were originally estimated for, and it became necessary to quarter the additional force on Davis Island. They were placed in the temporary buildings occupied by the laboring force during the construction of the work, but these buildings are no longer habitable. The extension of the guide crib below the lock is urgently requested by coal shippers, because at certain stages of the river there is an eddy below the lock, and an hour or two is sometimes lost before a fleet can get out of this eddy and proceed down the river.

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* Completed in 1889. † Completed in 1885.

Money statement.

July 1, 1891, balance unexpended		$317,057.10
Sale of property		243.71
		317,300.81
June 30, 1892, amount expended during fiscal year		259,114.37
July 1, 1892, balance unexpended		58,186.44
July 1, 1892, outstanding liabilities	$8,159.99	
July 1, 1892, amount covered by uncompleted contracts	16,331.13	
		24,491.12
July 1, 1892, balance available		33,695.32
Amount appropriated by act approved July 13, 1892		360,000.00
Amount available for fiscal year ending June 30, 1893		393,695.32
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		500,000.00

Abstract of proposals for riprapping levee at Shawneetown, Ill., opened September 1, 1891.

No.	Name and address of bidder.	Price per cubic yard.	Aggregate.
1	James Short, St. Charles, Mo	$1.50	$6,900.00
2	Frank Kirk, Madison, Ind	1.95	8,970.00
3	Kentucky Stone Ballast and Construction Company, Frankfort, Ky	2.15	9,890.00
4	B. R. Harsha & Co., Shawneetown, Ill	2.48	11,408.00

Contract awarded to James Short and executed under date of September 23, 1891.

Abstract of contracts for improving Ohio River made during the fiscal year ending June 30, 1892.

Contractor.	Work of improvement.	Date of contract.	To expire.
James Short	Riprapping southern levee at Shawneetown, Ill	Sept. 23, 1891	April 19, 1892

OHIO RIVER COMMERCE.

In connection with the commercial statistics, which are given farther on in this report, it is deemed pertinent, interesting, and valuable to give the following extracts from the last annual report of the superintendent of the Cincinnati Chamber of Commerce:

"The records for 1889–'90 showed a large gain in river business over previous years for quite a period, and this increase was maintained during 1890–'91 in both freight and passenger traffic. It is to be noted that this enlargement of volume of river commerce was due more to an increased movement of manufactures than of produce, there being some deficiencies in crops in the valley region. Southern products, including sugar, molasses, cotton, etc., contributed a liberal volume of freight.

"The revival of river commerce necessitated enlargement of transportation facilities, and during the year two steamers were rebuilt for the Cincinnati, Portsmouth and Pomeroy trade, two for the Cincinnati and Louisville Mail Line, and one new steamer built and one purchased for the Memphis and Cincinnati Packet Company; these three lines being practically under one management.

"With the additions mentioned, the equipment in these lines was better than previously during a period of six years, embracing seventeen boats, with a capacity of 11,700 tons, and representing about half of the tonnage engaged in the Cincinnati trade. There were daily departures (excepting Sundays) to Pomeroy, Portsmouth, Madison, and Louisville, and intermediate points, and two departures weekly to Memphis.

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"The Pittsburg and Cincinnati Packet Company, with an equipment of six steamers, made daily departures, except Wednesdays. The tonnage in this trade was 3,370 tons, and was fully employed. * * *

"The Southern Transportation line had five steamers in service, with a tonnage of 5,606 tons, making three departures every two weeks. The line had a good business up to the close of the season. The traffic of this line largely represents reshipments of goods from Pittsburg and lower Ohio business; also the movement of sugar, molasses, etc., from the South, these products showing the largest volume in any year since 1882. * * *

"The lines mentioned embrace the most important part of river transportation interests at Cincinnati. The Kanawha Packet Line made weekly trips to Charleston. The Chilo Packet made daily trips. There were tri-weekly departures to Petersburg.

"The year's business has been so satisfactory, following two years of improving returns for river transportation interests, that expectations have been greatly encouraged, and a further revival in river commerce is confidently looked for. The large increase in passenger traffic the past two years has occasioned decided improvements to be made in the building of new steamers for the accommodation and comfort of the traveling public. The equipment in the Cincinnati trade now compares favorably with river navigation facilities anywhere.

"With 1890-'91 there has been a period of three years of little interruption to the movement of steamers in the Cincinnati trade from low water, the record in this respect being quite exceptional. During this time there has been continuous communication by the largest steamers between Pomeroy and Louisville, and with but short interruptions in the Pittsburg and Memphis trades. The lowest stage of water recorded at Cincinnati during the time was 4 feet 5 inches. There have been no interruptions to steamers from ice since February, 1888, at this port and below, and only slight delays in the upper Ohio. The highest stage of water recorded at Cincinnati during the year was 57 feet 4½ inches, on February 25, which occasioned a few days' interruption to traffic, but not attended with serious damage to property or loss of river transportation." * * *

Coal shipments from Pittsburg, Pa.

[Furnished by Capt. William Evans.]

Months.	To Cincinnati.					To Louisville.				
	Trips.	Coal boats.	Coal barges.	Fuel flats.	Tons.	Trips.	Coal boats.	Coal barges.	Fuel flats.	Tons.
January	7	92	92	.....	43,862	13	63	77	2	93,540
February	3	2	7	2	39,873	1	.....	12	.....	39,568
March	10	.....	121	5	43,552	10	88	23	10	237,679
April	16	5	204	.....	105,093	18	82	133	9	142,995
May	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
June	65	55	669	1	359,547	71	287	623	37	575,095
July	20	12	233	.....	123,906	21	36	154	14	151,536
August	12	2	144	1	70,611	12	15	173	7	71,029
September	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
October	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
November	24	32	252	10	153,018	40	214	221	21	321,022
December	20	50	163	7	126,743	25	149	111	8	195,583
Total	176	250	1885	26	1,065,755	211	934	1527	108	1,828,047
Grand total	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,893,752

Comparative table showing coal shipments from Pittsburg during the eight years ending December 31, 1891.

Year.	To Cincinnati.	To Louisville.	Total.
1884	946,124	1,160,292	2,106,416
1885	1,733,104	1,114,008	2,847,112
1886	1,262,702	2,220,530	3,483,232
1887	788,690	1,367,012	2,155,702
1888	1,950,882	2,223,494	4,174,376
1889	1,149,892	1,439,747	2,589,639
1890	1,324,641	2,095,716	3,420,357
1891	1,065,705	1,828,047	2,893,752

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Commerce passing Davis Island Dam in 1891.

Vessels.	Ascending.				Descending.				Total freight.
	Through lock.	Freight.	Through pass.	Freight.	Through lock.	Freight.	Through pass.	Freight.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*Tons.*
Packets	141	15,560	415	46,680	140	15,630	423	46,890	124,760
Freight boats							4	1,200	1,200
Towboats	406		1,278		303		1,380		
Model barges	15		43		3		62	58,900	58,900
Coal boats	102		443		21	16,000	1,398	1,273,976	1,289,976
Barges	879	2,800	3,052	8,160	128	68,096	3,660	1,947,120	2,026,176
Flats	495	1,300	1,127	4,500	367	55,784	1,630	243,200	304,784
Rafts					25	17,300	59	52,109	69,409
Miscellaneous	33		54		50		70		
Total	2,071	19,660	6,412	59,340	1,037	172,810	8,656	3,623,395	3,875,205

River commerce of Cincinnati for the year ending August 31, 1891.

Articles.	Receipts.	Shipments.	Total.	Articles.	Receipts.	Shipments.	Total.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
Alcohol		74	74	Lead:			
Ale and beer		1,617	1,617	Pig		6	6
Apples	2,075	175	2,250	White		295	295
Bagging		14	14	Leather	299	92	391
Barley	36	2	38	Lemons		48	48
Beans	133	67	200	Lime	795	730	1,525
Beef		10	10	Lumber	6,620	2,120	8,740
Boots and shoes	18	500	518	Malt	22	46	68
Bran, etc	248	733	981	Manufactures		180	180
Broom corn		3	3	Merchandise	28,175	24,782	52,957
Butter	109	21	130	Molasses	7,207	4,094	11,301
Candles		31	31	Nails	33,478	18,908	52,386
Castings	1,744	1,924	3,668	Oats	5	320	325
Cattle	4,395	106	4,501	Oil	1,186	1,290	2,476
Cement	8,388	3,490	11,878	Onions	61	158	219
Cheese	2	66	68	Oranges	3	183	186
Cider	410	400	810	Peanuts	1,815	541	2,356
Coffee	57	1,347	1,404	Petroleum	865	1,412	2,277
Cooperage	674	392	1,066	Potatoes	951	882	1,833
Corn	584	972	1,556	Rice	204	138	342
Corn meal	3	708	711	Rope	879	1,327	2,206
Cotton	13,345	557	13,902	Rosin	5	99	104
Crockery	622	588	1,210	Rye	309	62	371
Eggs	748	29	777	Salt	16,028	8,147	24,175
Feathers	65	5	70	Seed, clover and timothy	93	867	960
Fish	7	944	951	Sheep	1,196	65	1,261
Flour	614	3,768	4,382	Shot		256	256
Fruit:				Soap	23	666	689
Dried	85	59	144	Sorghum	987	13	1,000
Green	1,611	67	1,678	Spices		7	7
Furniture		1,021	1,021	Starch	285	202	487
Glass, window	192	85	277	Stearine	19	6	25
Glassware	4,354	3,541	7,895	Sugar	1,026	2,693	3,719
Grease	299	219	518	Tallow	590	15	605
Hardware	2,510	2,988	5,498	Tea		8	8
Hay	3,046	516	3,562	Tobacco	19,309	2,765	22,074
Hides	315	106	421	Turpentine	2	18	20
Hogs	7,788	58	7,846	Vegetables, green	443	128	571
Hog product	16	2,657	2,673	Vinegar		1,260	1,260
Hops		8	8	Wheat	4,334	825	5,159
Horses	878	668	1,546	Whisky	8,861	6,483	15,344
Iron	14,150	10,266	24,416	Wines and liquors	190	366	556
Iron:				Wool	91	11	152
Pig	4,272	2,465	6,737	Yarn, cotton	446	66	446
Scrap	361		361				

Recapitulation.

	Tons.
Receipts	210,956
Shipments	125,831
Total	336,787

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Arrivals and departures of steamboats at the port of Cincinnati, Ohio.

Ports.	1885-'86.		1886-'87.		1887-'88.		1888-'89.		1889-'90.		1890-'91.	
	Arrivals.	Departures.	Arrivals.	Departures.	Arrivals.	Departures.	Arrivals.	Departures.	Arrivals.	Departures.	Arrivals.	Departures.
New Orleans	63	66	34	38	35	37	51	51	38	37	31	31
Pittsburg	103	103	69	70	156	153	237	237	197	194	208	207
Other ports	2,323	2,314	2,169	2,173	1,389	1,385	2,233	2,234	2,022	2,021	1,995	1,996
Total	2,489	2,483	2,272	2,281	1,580	1,575	2,521	2,522	2,257	2,252	2,234	2,234

Schedule of rates on flour per barrel by rail and river from Cincinnati for six years ending August 31, 1891.

Destination.	1886.		1887.		1888.	
	By rail.	By river.	By rail.	By river.	By rail.	By river.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Pittsburg	26 to 31	15 to 20	24 to 31	15	22 to 24	15
Louisville	15	15	15	15	15	15
New Orleans	44	35 to 39	44 to 49	35	40 to 49	35

Destination.	1889.		1890.		1891.	
	By rail.	By river.	By rail.	By river.	By rail.	By river.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Pittsburg	23	15	23 to 24	15	24	15
Louisville	15	15	15	15	15	15
New Orleans	54	35	49 to 54	35	49	35

Comparative statement of commerce passing the falls of the Ohio River by canal and by river.

Years.	Canal.		Open river.		Total.	
	Vessels.	Tons.	Vessels.	Tons.	Vessels.	Tons.
1882	3,988	935,628	2,305	668,866	6,293	1,604,494
1883	5,231	1,349,115	1,484	483,281	6,715	1,832,396
1884	3,485	785,192	1,548	484,124	5,033	1,269,316
1885	5,678	1,443,181	822	262,862	6,500	1,706,043
1886	4,964	1,240,112	1,796	577,547	6,760	1,817,659
1887	4,069	867,807	2,297	1,204,518	6,366	2,072,325
1888	6,963	1,915,365	2,252	1,162,305	9,215	3,077,670
1889	5,534	1,404,573	1,984	957,829	7,518	2,362,402
1890	4,386	998,062	3,828	1,717,158	8,214	2,715,220
1891	4,739	1,302,471	2,137	1,062,428	6,876	2,364,899

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Commerce of Ohio River in 1891.

Name of boat or company.	Between what points on the Ohio River.	Distance on Ohio River.	Number of months in commission.	Freight.	Number of passengers.
		Miles.		*Tons.*	
Coal shipments from Pittsburg	Pittsburg to Cairo	965	9	2,893,752	.....
Tennessee River Navigation Co	.....do	965	8	24,104	.....
Huntington and St. Louis Towboat Co.	.....do	965	12	166,896	.....
A. Montgomery & Co	.....do	965	10	223,740	.....
The Marmet Co	Pittsburg to Louisville	599	10	139,106	.....
Steamboat Hawk	.....do	599	6	58,880	.....
Steamboat Hudson	Pittsburg to Cincinnati	467	9	30,157	9,157
Steamboat Keystone State	.....do	467	9	29,221	8,360
Steamboat Scotia	.....do	467	8	14,880	5,920
Steamboat Andes	.....do	467	6	13,250	3,382
Steamboat C. W. Batchelor	.....do	467	8	14,850	3,300
Steamboat Congo	.....do	467	8	17,846	6,282
Steamboat Louise	Pittsburg to Portsmouth	354	4	1,692	842
Steamboat Lizzie Bay	Pittsburg to Gallipolis	267	10	12,600	5,500
Steamboat New Courrier	Pittsburg to Parkersburg	183	10	2,813	11,025
Steamboat Ben Hur	.....do	183	7	7,801	9,511
Steamboat H. K. Bedford	Pittsburg to Wheeling	90	10½	7,500	4,559
Steamboat Leni Leoti	Pittsburg to McKees Rocks	3½	12	735	79,382
Steamboat Venice	.....do	3½	10	470	63,192
Steamboat Venus	.....do	3½	12	820	86,357
Steamboat Olivette	East Liverpool to Steubenville	23	6	1,900	5,843
Steamboat R. E. Phillips	Wheeling to Bellaire	4	10	3,000	50,000
Steamboat Liberty	Wheeling to Clarington	28	12	14,100	8,156
Steamboat Eliza H	Wheeling to Parkersburg	93	12	36,608	.....
Cincinnati Sand and Gravel Co	Wheeling to Cincinnati	376	12	65,500	.....
Steamboat T. N. Barnsdall	Raven Rock to Marietta	23	10	2,600	9,600
Steamboat T. M. Bayne	Marietta to Parkersburg	13	10	2,945	15,560
Steamboat Bob Ballard	Marietta to Gallipolis	96	3½	2,980	1,325
Steamboat Matt F. Allen	.....do	96	1	675	500
Steamboat Mary E	Parkersburg and vicinity	.....	3	5,022	.....
Steamboat Jessie	Parkersburg to Louisville	415	12	5,760	.....
Steamboat Valley Belle	Ravenswood to Middleport	34	8	8,320	6,241
I. R. Ware	Ravenswood to Warsaw	304	12	29,021	.....
Steamboat Capitol City	Letart to Gallipolis	33	10	9,000	4,500
Syracuse Coal Co	Syracuse to Cincinnati	224	12	35,947	.....
John Barrett & Son	Pomeroy to Cairo	718	10	377,000	.....
Pomeroy, Cincinnati & Louisville Barge Line.	Pomeroy to Louisville	351	8	160,000	.....
Buena Vista Freestone Co	Pomeroy to Cincinnati	219	12	20,100	.....
Juhling Coal Co	.....do	219	12	20,000	.....
Cincinnati and Pomeroy Packet Co.*	.....do	219	10	132,289	51,329
Cole & Collins	.....do	219	8	133,250	.....
Armstrong Bros	Point Pleasant to Louisville	336	10	80,000	.....
Great Kanawha Towboat Co	Point Pleasant to Cairo	703	6	28,800	.....
Collier Budd & Co	Point Pleasant to Cincinnati	203	12	31,104	.....
Kanawha and Ohio Transportation Co.	.....do	203	10	181,336	.....
Ella Layman Towboat Co	.....do	203	10	287,500	.....
Steamboat Henry M. Stanley	.....do	203	10	15,620	10,200
Thomas Hall	Gallipolis to Louisville	332	12	18,700	.....
Steamboat Ida Smith	Crown City to Ironton	37	7	1,120	3,920
Steamboat B. T. Enos	Proctorville to Portsmouth	53	10	7,500	6,000
Steamboat F. J. O'Connell	Guyandotte to Coal Grove	18	10	35,000	.....
Steamboat Chevalier	Huntington to Ironton	19	12	100	17,306
Ashland Coal and Iron Rwy. Co.	Ashland to Portsmouth	33	10	54,640	.....
Steamboat Mink No. 2	Ashland to Cincinnati	147	10	10,000	.....
Steamboat Reliance	Portsmouth to Rome	27	11	3,000	8,535
Steamboat Silver Wave	Vanceburg to Maysville	30	11	3,500	16,500
Cole & Collins	Manchester to Cincinnati	72	12	65,196	.....
Steamboat M. P. Wells	Maysville to Augusta	20	10	1,500	18,000
John Trapp	Charleston Bar to Covington	55	10	14,000	.....
Steamboat Tacoma	Chilo to Cincinnati	35	10½	13,800	18,768
Steamboat Pauline	Blairsville to Desiccating Factory	24	12	150,000	.....
The Coney Island Co	Coney Island Landing to Cincinnati.	10	3	525	287,521
Henry Spille & Son	Dayton to Cincinnati	3	8	20,000	.....
Steamboat Bellevue	Dayton to Cincinnati	3	12	.....	309,329
Steamboat Levi J. Workum	Cincinnati to Petersburg	25	12	9,540	886
R. H. Fleming	Cincinnati and vicinity	.....	12	20,418	.....
U. S. Mail Line Co.†	Cincinnati to Louisville	132	12	158,510	127,266
Steamboat B. F. Young	Cincinnati to Paducah	455	1	800	.....

* One boat to Portsmouth ten months.

† Two boats from Cincinnati to Madison, one boat from Warsaw to Madison, and two boats from Carrollton to Louisville.

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Commerce of Ohio River in 1891—Continued.

Name of boat or company.	Between what points on the Ohio River.	Distance on Ohio River.	Number of months in commission.	Freight.	Number of passengers.
		Miles.		*Tons.*	
Memphis and Cincinnati Pk. Co.	Cincinnati to Cairo	499	10	73,902	11,762
Steamboat U. P. Schenck	do	499	6½	9,625	453
Steamboat State of Missouri	do	499	5	11,000	275
Steamboat State of Kansas	do	499	1	1,900	113
Steamboat New Mary Houston	do	499	7	14,700	1,540
Steamboat Guiding Star	do	499	5	11,750	975
Steamboat Golden Rule* (estimated).	do	499	7	14,000	1,200
Steamboat Falls City	Carrollton to Louisville	58	12	21,656	4,923
Steamboat City of Clarksville	do	58	10	5,220	1,860
Steamboat Bellaire	Madison to Louisville	47	8	4,500	10,000
Louisville and Evansville Mail Co.	Louisville to Henderson	197	12	105,958	38,441
Steamboat Judelle	Cannelton to Owensboro	32	12	6,260	12,520
Steamboat Royal	Owensboro to Henderson	46	8	2,873	34,275
John Ingle & Co	Mouth Green River to Evansville	8	12	350,000	10,500
Steamboat T. C. Woodward	do	8	10	700	3,200
Steamboat Fannie	do	8	1	175	575
Steamboat Frank Stein	Evansville to Henderson	12	12	2,100	27,500
Steamboat John S. Hopkins	Evansville to Paducah	137	12	17,000	15,980
Steamboat Joe Fowler	do	137	12	16,400	16,120
Steamboat W. F. Nisbet	do	137	12	25,508	5,760
Steamboat D. A. Brooks	Evansville to Cairo	182	12	33,216	7
Steamboat City of Metropolis	Paducah to Metropolis	9	12	2,250	16,266
Steamboat Gus Fowler	Paducah to Cairo	45	12	67,600	8,580
Steamboat Luella Brown	do	45	8½	520	18,060
Steamboat City of Sheffield	do	45	10	20,670	1,170
Steamboat City of Savannah	do	45	12	21,600	1,500
Steamboat City of Paducah	do	45	6	10,878	558
Southern Transportation and Lumber Co.	Brooklyn to Cairo	42	1	62	.....
Sea Lion Towboat Co	Catlettsburg to Louisville	284	10	485,159	.....
Total		.....	.....	7,276,516	1,518,167

* Boat burnt with books and papers.

Tonnage from which no report can be obtained (estimated).

	Tons.
Logs, lumber, and railroad ties towed and rafted	1,000,000
Flatboats: corn, oats, hay, apples, potatoes, cabbage, cider, tan bark, hoop poles, etc	50,000
Trading boats: glass and stone ware, dry goods, groceries, oil, hides, pelts, oil barrels, scrap iron, old rope, etc	15,000
Total	1,065,000

D D 2.

OPERATING SNAG BOATS ON OHIO RIVER.

The river and harbor act of September 19, 1890, contained the following item:

SEC. 13. That for the purpose of securing the uninterrupted work of operating snag boats on the Ohio River, and removing snags, wrecks, and other obstructions in said river, the Secretary of War, upon the application of the Chief of Engineers, is hereby authorized to draw his warrant or requisition from time to time upon the Secretary of the Treasury for such sums as may be necessary to do such work, not to exceed in the aggregate for each year the sum of twenty-five thousand dollars: *Provided, however,* That an itemized statement of said expense shall accompany the Annual Report of the Chief of Engineers.

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The purpose of the above law was frustrated during the latter part of the calendar year 1891 and the first half of the calendar year 1892, due to the fact that, in addition to the usual annual repairs, a battery of new boilers and some betterments to the snag boat *E. A. Woodruff* consumed two-thirds of the money allowed for operating expenses of the boat for a whole year.

The above-mentioned work was contracted for in May, 1891, and was to have been completed and paid for out of the funds available for the fiscal year ending June 30, 1891, but in consequence of unavoidable delays in the delivery of material to the contractors, these several jobs were not completed until the latter part of August, 1891, necessitating payments for the work which, including pay of crew and amounting to $15,773.70, had to be taken from funds available for the fiscal year ending June 30, 1892, which left only $9,226.30 to pay the current expenses of the snag boat and the outside expenditures for the year.

After deducting the outside expenditures and the cost of taking care of the snag boat during the winter months from the balance on hand, and considering the monthly expenses of the snag boat in commission, it became evident that the boat could not be kept in commission later than November 30, 1891. The snag boat was therefore ordered put in winter quarters, in the mouth of the Kentucky River, not later than December 1, 1891, where she was compelled to remain until the appropriation for the next fiscal year should become available.

In submitting the annual report of the Ohio River snag boat *E. A. Woodruff*, it has been deemed best to continue the practice of reporting the operations of the boat by calendar years, as by this means the report of each season's work is presented by itself, while if the report is made for the fiscal year it must necessarily include parts of two seasons' work, which is less satisfactory. It is evidently necessary, however, in view of the limit to annual expenditures, to report the latter by fiscal years. The present report of operations is for the calendar year 1891, and the report of expenditures covers the fiscal year from July 1, 1891, to June 30, 1892.

The work of the United States snag boat *E. A. Woodruff* has been under the supervision of Capt. W. H. Christian.

OPERATIONS.

(EXTRACT FROM THE REPORT OF CAPTAIN W. H. CHRISTIAN.)

After undergoing her annual repairs at Cincinnati, the United States snag boat *E. A. Woodruff* began her season's work on the Ohio River on the 8th day of September, 1891; she descended the river as far as Cullum Bar and removed part of a steamboat and three coal-barge wrecks and seven snags from the new channel made on the Kentucky side of the river by the dike recently built at that point. On the 11th of September she ascended the river as far as Wheeling, W. Va., and then, being prevented by low water and a falling river from proceeding to Pittsburg, worked her way down stream to Flint Island, 684 miles below Pittsburg, arriving at that place on November 22. Returning she ran up stream to winter quarters in the mouth of the Kentucky River, where she went out of commission on the 27th of November.

During the short working season the *Woodruff* removed 473 snags, 9 steamboat wrecks, 24 coal boats, barges, and flats, 1 brick boat, 1 model barge, 1 ferry-boat hull, 11 rocks, 1 mass of pudding stone, 3 large pieces of iron wreckage of the Chesapeake and Ohio Railway bridge at Cincinnati. Considerable time was spent in dragging with hook and chain over wrecks nearly covered with earth and in breaking the crust of sand and gravel bars to assist scouring. Total distance traveled during the season was 1,396 miles.

Among the most dangerous obstructions removed may be mentioned two large rocks at the foot of Eightmile Island; two in front of Proctorville, Ohio; three in front of upper end of Ironton, Ohio; the steamboat *Nail City* in front of Catletts-

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burg, Ky.; steamboat *Storm* in front of upper end of Ironton, Ohio; steamboat *John R.* at the foot of Brush Creek Island; one large stump from the new channel at Cullums Bar; a model barge at Flint Island; one large snag from channel in front of upper end of Greenupsburg, Ky., which had sunk two boats and damaged several; one snag from channel at Ninemile Bar, which sunk steamboat *Bostona.*

REMOVAL OF SNAGS, WRECKS, AND OTHER OBSTRUCTIONS IN THE OHIO RIVER.

In addition to the work done by the snag boat *E. A. Woodruff*, a large number of rocks that obstructed the navigation of the Ohio River, near Catlettsburg, Ky., were removed by a gang of men hired for that purpose.

A steam dredge was also hired, and worked fourteen and one-half days at Cullums Ripple, removing obstructions from the channel of the river at that place.

Itemized statement of expenses for operating snag boats on the Ohio River, and removing snags, wrecks, and other obstructions in said river.

EXPENSES OF U. S. SNAG BOAT E. A. WOODRUFF.

Month.	Pay of crew.	Subsistence.	Fuel.	Miscellaneous supplies.	Tools and implements.	General repairs.	Contingent expenses.	Total.
July, 1891	$1,570.22	$6.35	$29.92	$12.64		$395.26		$2,014.39
August, 1891	1,617.91	253.99	38.03	386.00	$10.00	7,049.88		9,355.81
September, 1891	2,076.86	365.54	364.86	8.88		387.37	$14.54	3,218.05
October, 1891	2,051.44	629.00	247.14	126.93	17.00		57.50	3,129.01
November, 1891	1,898.46	358.60	333.74	29.10	4.00		64.00	2,687.90
December, 1891	415.22	19.69						434.91
January, 1892	400.00	22.21						422.21
February, 1892	400.00	19.96					10.80	430.76
March, 1892	275.00	19.17					2.10	296.27
April, 1892	187.50	33.94					2.10	223.54
May, 1892	100.00	1.15		1.00				102.15
June, 1892	166.77							166.77
Total	11,159.38	1,729.60	1,013.69	564.55	31.00	7,832.51	151.04	22,481.77

Other expenditures.

Removing snags, wrecks, and other obstructions from Ohio River near Catlettsburg, Ky	876.63	
Removing snags, wrecks, and other obstructions from Ohio River at Cullums Bar	590.00	
Outstanding liabilities July 1, 1891, paid during fiscal year	1,287.15	
		2,753.78
Total expenditures for removal of snags, wrecks, and other obstructions		25,235.55

D D 3.

OPERATING AND CARE OF DAVIS ISLAND DAM, OHIO RIVER, NEAR PITTSBURG, PENNSYLVANIA.

This work has been under the immediate supervision of Mr. William Martin, assistant engineer.

The following is a statement of the amount and date of all allotments for this work:

August 3, 1885	$5,865.00	May 19, 1890	$2,000.00
July 10, 1886	12,015.00	June 17, 1890	14,752.00
January 28, 1887	6,700.00	October 7, 1890	14,800.00
July 1, 1887	12,355.00	July 10, 1891	10,338.00
February 25, 1888	3,500.00		
July 11, 1888	18,015.00	Total	112,413.00
August 20, 1889	12,073.00		

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At the close of the last fiscal year the dam was up, having been raised on June 30, 1891. The maneuvers during the year were as follows:

Lowered the dam, July 8.
Raised the dam, July 15.
Lowered the dam, July 24.
Raised the dam, August 10.
Lowered the dam, August 24.
Raised the dam, September 2.
Lowered the dam, November 24.
Raised the dam, June 30.

At the end of the year the dam was up.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM THE REPORT OF MR. WILLIAM MARTIN.)

Lock.—The lower rail, in the recess of the lower lock gate, which showed evidence of weakening at the close of the last fiscal year, came off entirely in September, and in the month of October, when the stage of water was at its lowest, it was renewed by a new rail of heavier section. To do this required closing the recess by a coffer-dam and pumping out the inclosure.

The old rail fit into a rabbet in a 3¼-inch timber which rested on the masonry. When this rail, which was three-quarter by 6 inches, came off, the lock gate wheels cut into and through the timber and were soon running on the stone masonry, which being 3¼ inches lower than the track level strained the gate and made it run very hard. A new steel rail, 3 by 11 inches, was substituted for the old rail and the 3¼-inch oak timber, and was raised above the rough masonry surface one-quarter of an inch by wedges, thus bringing the new rail to the proper level.

During the period of putting in the new rail, between the 12th and 19th of October, the stage of water was so low that the boats could not run, so no interference to navigation was caused by having the lock closed for the period stated. At 12:50 a. m., on the morning of the 13th of September, the passenger steamer *Courier* descending ran into the lock under full head and, crashing into the lower lock gate, broke the upper chord of the gate truss, the top rail, one of the vertical posts, and the large oak timber to which the lock gate chain is attached. The captain and pilot of the boat were arrested and the boat libeled. At the hearing before the United States Commissioners the officers of the boat were charged with wilful carelessness, but for lack of sufficient testimony to prove the charge they were dismissed. The libel against the boat has not yet been disposed of.

Service pump.—The contract for building a new service pump to replace the old one, for use in supplying water for the tanks for operating the lock-filling and discharging valves, was let August 8 to The Hall Steam Pump Company, of Allegheny City, Pa. The design of the pump was prepared in this office, and dated May 19, 1891.

The old pump was of the vertical piston class, and was poorly adapted to the work it had to perform, having to work against a head of 65 feet. The new pump is of the plunger class, of more substantial build, and better adapted to the work. It is completed but not yet erected, as the high water interfered before the work was completed.

Drift chute.—The drift chute constructed through the lower wall of the lower back gate recess performs a great service in freeing the recess of all drift which is naturally drawn into it by the operation of the lock-discharging valves. By its use the drift is quickly passed below the lock and out of the way. I hope next year to have a similar plan carried out in respect to the recess of the upper gate, as at the latter place the greatest annoyance is experienced from this cause.

Stone in land wall inclosure.—About 25 cubic yards of large stone, left over from the construction of the bear-trap piers and which had been stored in the land lock wall inclosure, were removed and deposited in the river bed below the bear trap, thus adding to the protection of the river bed at this point.

Movable dam.—On the evening of the 8th of August, 1891, we began to raise the dam. Fourteen wickets next to the river wall were raised, when operations were suspended until the next morning. On the outer wicket a red signal light was placed to warn navigators. The towboat *Nellie Walton*, ascending at 10:15 p. m., with a tow of empty barges, ran into these wickets and knocked four of them down. An examination showed that four wicket boxes, three cross heads, three quoins, and nine wicket-box bolts were broken and the horses badly bent. The excuse the officers of the boat gave was that they did not see the signal light. This accident delayed the raising of the dam, as the repairs of the damage done required two days' time.

Otherwise the condition of the chanoine and bear-trap dams has been good throughout the year. There were no delays to navigation from any cause in connection therewith.

An improvement in the bear-trap dam could be made by extending the piers upstream about 71 feet, making a total length up the river from the crest of the dam of 100 feet. This would distribute the fall of the water over a long distance and reduce the weight on the gates, thus lessening the resistance to their rising. In the present condition of the dam the piers are only 29 feet upstream from the crest of the dam. This distance is so short that there is but 12 inches reduction in the head when the gates are down, and the resistance to the gates rising being largely increased by the velocity of the water passing through the chute, makes the downward force greater than the lifting power. As a matter of fact, when necessity requires the bear-trap to be lowered under full head for the purpose of passing drift or otherwise, the pool has to be drawn off 6 inches below the normal level before the gates can be raised again. With the piers extended upstream as suggested, the difficulties we now labor under would be overcome.

Scour below the dam.—No injurious effect from scour below the dam has been observed during the year. The old barges, loaded with stone and sunk at the points where the dangerous scour of August and September, 1890, took place, have remained intact.

Back River Dam.—This dam, which closes the stream between Davis Island and the south shore of the river, is a permanent structure, and is in good condition.

Natural gas.—The supply of natural gas for light and fuel is still received from the Bellevue and Glenfield Natural Gas Company at the same rate per annum as paid last year, viz, $350.

Operation of dam.—The dam was up on July 1, 1891, and was maneuvered during the year on the following dates:

Lowered July 8, July 24, August 24, and November 24, 1891.

Raised July 15, August 10, September 2, 1891, and June 30, 1892.

Duration in days of the various stages of water in the Ohio River at the Davis Island Dam from October 7, 1885, to the close of the fiscal year June 30, 1892, is shown by the accompanying table:

Month.	1885–'86.			1886–'87.			1887–'88.			1888–'89.			1889–'90.			1890–'91.			1891–'92.		
	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.	Under 3 feet.	3 feet and over.	6 feet and over.
July	...	...	...	7	24	0	21	10	0	3	28	8	0	31	13	14	17	1	0	31	13
August	...	...	...	7	24	3	27	4	0	13	18	6	5	26	2	13	18	9	0	31	12
September	...	...	...	19	11	0	30	0	0	1	29	6	18	12	0	0	30	21	9	21	4
October	12	19	7	26	5	0	30	1	0	1	30	23	6	25	3	0	31	31	20	11	0
November	0	30	22	12	18	16	19	11	0	0	30	26	0	30	30	0	30	29	9	21	7
December	0	31	27	0	31	22	2	29	0	0	31	18	0	31	31	0	31	17	0	31	29
January	0	31	28	0	31	17	1	30	19	0	31	30	0	31	31	0	31	31	0	31	22
February	0	28	21	0	28	28	0	29	26	0	28	13	0	28	28	0	28	28	0	29	27
March	0	31	17	0	31	18	0	31	29	0	31	29	0	31	31	0	31	31	0	31	29
April	0	30	21	0	30	13	0	30	25	0	30	25	0	30	26	0	30	26	0	30	30
May	0	31	11	0	31	16	0	31	13	0	31	21	0	31	31	1	30	0	0	31	29
June	2	28	5	3	27	7	1	29	2	0	30	30	0	30	21	0	30	21	0	30	22
Year	14	259	159	74	291	140	131	235	114	18	347	235	29	336	247	28	337	245	38	328	224

River gauge stations.—During the period of the year the dam is up we receive warnings of the condition of the upper river for use in operating the dam, daily about 10 o'clock a. m., from the weather bureau in Pittsburg, Pa., comprising seventeen stations. In the evening special reports are received, at 5:30 p. m., from five stations, viz: Freeport and Parker, Pa., on the Allegheny; Greensboro and Lock No. 4, Pa., on the Monongahela; and West Newton, Pa., on the Youghiogheny River. These special reports are received regularly every evening, except in times of a rising river, when they are received hourly or as often as called for. The gauge observers at the different stations are paid by the message, and the amount earned per month depends upon the number of messages sent. This, at the maximum, is not enough to justify as close attention to the business as the navigation interests demand. The system is capable of great improvement,

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Estimate for fiscal year ending June 30, 1893.

Salaries and wages	$8,160.00
Water gauge reports	200.00
Telephone	240.00
Telephone messages	200.00
Natural gas for light and fuel	350.00
Oils	50.00
Diver	60.00
Post-office box	8.00
Materials	275.00
Repair of upper porch, lock-keeper's house	550.00
Service pump, fitted up	840.89
Contingencies	1,000.00
Total	11,933.89

Detailed statement of expenses incurred at the Davis Island Dam, Ohio River, during the fiscal year ending June 30, 1892.

Month.	Operating expenses.				Maintenance and repairs.					Grand total.
							Plant.			
	Salaries.	Supplies.	Miscellaneous expenses.	Total.	Labor.	Material.	Purchase and repairs.	Hire.	Total.	
1891.										
July	$774.38	$29.16	$61.35	$864.89		$6.30	$59.64		$65.94	$930.83
August	690.50	55.49	70.65	816.64			7.46		7.46	824.10
September	695.00	35.87	68.60	799.47			171.09		171.09	970.56
October	673.00	29.16	37.80	739.96	$116.50		600.18	$84.00	800.68	1,540.64
November	680.00	43.08	85.60	808.68			5.50		5.50	814.18
December	651.67	65.16	70.88	787.71			4.25	15.00	19.25	806.96
1892.										
January	610.00	40.54	22.00	672.54						672.54
February	627.33	29.17	21.75	678.25			7.28		7.28	685.53
March	645.00	29.17	20.00	694.17			91.74		91.74	785.91
April	640.00	31.25	33.39	704.64			31.83		31.83	736.47
May	656.00	40.50	20.67	717.17		12.05	15.10		27.15	744.32
June	690.50	29.17	20.66	740.33						740.33
Total	8,033.38	457.72	533.35	9,024.45	116.50	18.35	994.07	99.00	1,227.92	10,252.37

D D 4.

MOVABLE DAM IN OHIO RIVER BELOW MOUTH OF BEAVER RIVER, PENNSYLVANIA.

The first appropriation for this work was made September 19, 1890, $250,000.

This dam, which is located 30 miles below Pittsburg, Pa., will be the sixth in the series of movable dams for improving the Ohio River by slackwater navigation. Davis Island Dam, located 5½ miles below Pittsburg, and which has been in successful operation since October, 1885, is the first of the series.

This work has been under the immediate supervision of Mr. William Martin, assistant engineer.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM THE REPORT OF MR. WILLIAM MARTIN.)

A survey for the location and soundings of the Beaver Dam was made March 17, 1891, and represented by the map dated March 24, 1891.

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In October the river was at a very low stage and many of the levels of the river bed were retaken on dry land, the stage of the water permitting the wading of the river. These levels being very accurate were substituted for the soundings represented by the map of March 24 above mentioned.

The land necessary for the construction of the lock and abutment was obtained by purchase after condemnation. The tract on the north side of the river, for the construction of the lock and its approaches, containing six acres, was purchased from Mr. James McTaggart; that on the south side, containing 3.46 acres, belonged to the Beaver County Infirmary, and was controlled by a board of directors. This board was created by act of assembly of March 29, 1851, and by its terms no authority is given the board to sell any of the property acquired for the purposes of the act. Accordingly a board of appraisers was appointed by the court for the purpose of condemning the necessary land. By the appraisers report $166¾ per acre was agreed upon, being the same price per acre as paid to Mr. McTaggart for the land on the north side of the river. At this price the total cost to the United States for the land needed for the lock and dam was $1,576.67. This has been paid and the title vested in the United States.

The reference of the sill of the Beaver Dam, as fixed by the diagram of the profile of the Ohio River from Davis to Montgomerys Island, dated February 24, 1891, is 655.871 feet above mean tide.

Borings to determine the character of the foundation were made on the site of the location. No rock was encountered except at a few points, the strata in all cases being from two to three feet in thickness. The material passed through consists of clay, gravel, and sand, sandstone, a dark shale resembling coal, and some indications of quicksand.

The preliminary work of construction was begun with a small force on the 26th of June, 1892, by clearing and cross-sectioning the land of the site and erecting water gauges for hydrographic purposes.

It is expected that the construction of the lock will be well advanced during the present season.

Money statement.

July 1, 1891, balance unexpended	$248,618.77
June 30, 1892, amount expended during fiscal year	5,364.01
July 1, 1892, balance unexpended	243,254.76
July 1, 1892, outstanding liabilities	123.92
July 1, 1892, balance available	243,130.84
Amount appropriated by act approved July 13, 1892	100,000.00
Amount available for fiscal year ending June 30, 1893	343,130.84
Amount (estimated) required for completion of existing project	550,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	250,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

DD 5.

IMPROVEMENT OF MONONGAHELA RIVER, WEST VIRGINIA AND PENNSYLVANIA.

Statement of the amount and date of all appropriations.

June 10, 1872	$25,000	March 3, 1881	25,000
March 3, 1873	66,000	August 2, 1882	25,000
June 23, 1874	25,000	July 5, 1884	45,000
March 3, 1875	22,000	August 5, 1886	90,900
June 18, 1878	25,000	August 11, 1888	35,000
March 3, 1879	24,000		
June 14, 1880	25,000	Total	432,900

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The original project for the improvement of the Monongahela River was the construction of two locks and dams to continue slackwater navigation from the head of slackwater of the Monongahela Navigation Company to Morgantown, W. Va. These locks and dams are completed and in operation.

This work has been under the immediate supervision of Mr. Philip Golay, assistant engineer, and the information relating to the operations of the year is obtained from his report.

At the beginning of the fiscal year there remained available of these appropriations the sum of $752.13. Two cisterns, having a capacity of about 200 barrels each, have been constructed in rear of the lock-keepers' dwellings during the fiscal year. It is proposed to expend the small balance remaining in making some minor additions and improvements on the work.

Money statement.

July 1, 1891, balance unexpended	$801.66
June 30, 1892, amount expended during fiscal year	443.18
July 1, 1892, balance unexpended	358.48
Amount appropriated by act approved July 13, 1892*	25,000.00
Amount available for fiscal year ending June 30, 1893	25,358.48

Commercial statistics.

The following table shows the commerce that passed through United States Lock No. 8 during 1891:

Month.	Ascending.		Descending.	
	Passengers.	Freight.	Passengers.	Freight.
		Tons.		*Tons.*
January	357	336.95	342	102.60
February	357	291.75	331	525.78
March	373	183.25	469	2,679.50
April	391	165.55	410	1,729.85
May	606	287.20	604	3,907.29
June	557	546.50	635	2,877.35
July	1,763	561.25	1,653	1,811.55
August	1,943	195.23	2,058	1,686.80
September	791	224.25	923	2,012.11
October	547	180.05	614	1,743.45
November	467	140.35	463	921.59
December	356	157.70	413	792.55
Total	8,518	3,270.03	8,915	20,790.42

* For beginning work on lock and dam No. 10.

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The following table shows the commerce that passed through United States Lock No. 9 during 1891:

Month.	Ascending.		Descending.	
	Passengers.	Freight.	Passengers.	Freight.
		Tons.		*Tons.*
January	368	451.70	320	29.25
February	363	235.12	307	245.70
March	393	379.30	400	478.15
April	357	397.16	349	999.50
May	431	397.60	393	3,045.00
June	618	525.25	609	744.50
July	1,599	690.85	1,361	330.41
August	1,991	474.00	1,733	643.07
September	890	458.20	863	714.00
October	600	706.95	541	901.90
November	478	488.40	427	741.60
December	389	388.80	359	845.05
Total	8,477	5,593.33	7,662	9,218.13

Taking the average of the totals given in the above tables we find that the commerce during 1891 on the 14 miles of the Monongahela River which is controlled by the United States is as follows:

Tons of freight 19,436
Passengers 16,786

The following table compiled from the annual reports of the Monongahela Navigation Company shows the commercial movement on the lower part of this river for the past eight years.

Articles.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Brick	1,467	1,325	8,997	5,279	4,504	6,333	7,856	7,897
Cattle and horses	108	374	386	501	565	729	648	783
Classified freight	13,890	13,683	13,086	16,486	17,450	18,334	23,169	21,746
Coal and coke	3,104,860	3,265,078	4,297,768	2,998,690	4,400,996	3,084,175	4,486,322	4,291,674
Fire clay	2,140	3,463	3,295	2,383	3,476	5,982	5,021	6,193
Hogs	254	138	83	259	379	266	340	302
Iron:								
Ore	20,840	16,486	17,823	17,683	8,079	3,371	2,335	.....
In pigs	17	11	5	7	10	15	5	3
Lumber	10,714	9,622	10,231	11,144	13,778	10,095	11,615	25,887
Oil	9	1,073	.....	55	.....	.....	.....	.....
Pipe	.....	595	.....	2,285	.....	.....	2,394	.....
Posts	5	256	437	258	489	700	1,069	4,910
Posts pit	35,072	32,166	18,392	30,472	22,432	18,707	29,336	9,786
Railroad ties	1,256	135	161	30	555	3,165	232	160
Sand	37,345	51,771	59,229	89,230	63,085	73,590	105,600	74,600
Sheep	170	134	108	233	193	164	60	112
Staves	.....	9	9	.....	7	26	140	109
Steel rails	23,844	22,428	45,795	37,490	10,688	32,177	34,609	11,422
Stone	56,116	7,612	4,621	910	3,636	9,580	811	4,595
Timber	47,064	46,172	52,698	53,561	84,191	54,696	43,970	67,164
Whisky	254	198	164	49	88	134	180	922
Wood	.....	230	196	.....	184	.....	58	.....
Total	3,355,425	3,472,959	4,533,484	3,287,005	4,634,785	3,322,239	4,755,790	4,528,465
Passengers	26,871	24,698	26,885	50,584	44,714	45,811	31,828	48,744

D D 6.

OPERATING AND CARE OF LOCKS AND DAMS NOS. 8 AND 9, MONONGAHELA RIVER.

The Monongahela River, from Morgantown, W. Va., to its mouth at Pittsburg, is canalized by nine locks and dams, of which the first seven, counting from Pittsburg, are the property of the Monongahela Naviga-

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tion Company, and the eighth and ninth are the property of the United States. The eighth dam is 88.15 miles above Pittsburg, and Morgantown, the head of the slackwater, is 102.16 miles from the same. It may, therefore, be stated that 14 miles of this river is under the direct control of the United States and 88 miles is under a private corporation.

The following is a statement of date and amount of all allotments for this work:

August 5, 1884	$1,000
September 1, 1884	4,000
November 3, 1884	4,500
December 20, 1884	500
June 1, 1885	100
July 22, 1885	1,000
July 15, 1886	1,200
March 1, 1887	1,100
July 1, 1887	11,000
July 11, 1888	6,270
October 27, 1888	3,000
July 17, 1889	1,480
October 7, 1889	1,500
November 8, 1889	1,200
July 24, 1890	12,300
July 9, 1891	24,250
September 25, 1889, from appropriation for examinations, surveys, and contingencies of rivers and harbors	4,000
	78,400

The only stoppage to navigation throughout the year was on account of ice and high water during a few days in midwinter.

This work has been under the immediate supervision of Mr. Philip Golay, assistant engineer, and the information relating to the operations of the year is contained in his report.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM REPORT OF MR. PHILIP GOLAY.)

Early in the spring of 1890 the aprons of both dams were injured by floods, but on account of continued high water it was impossible to repair them during that year. The past year has been a little more favorable for such work, and repairs were made on both dams.

LOCK AND DAM NO. 8, MOUTH OF DUNKARD CREEK.

Repair of dam.—The injury sustained by Dam No. 8 was confined to the middle portion. Two sections of the dam, one 64 feet long next to the lock, and one 58 feet long next to the abutment, showed no signs of injury. On the intervening section, 466 feet long, the damage, beginning with the lifting of a small portion of the apron sheeting, increased with subsequent rises of the river until it extended across the dam, lifting the sheeting together with all the purlins except the one on the upstream side which was held in place by the sheet piling spiked to it. Also a few timbers of the apron substructure were carried away.

Additional anchorage was given to the toe of the apron of the uninjured parts; while, of the middle part, the apron sheeting was removed and the apron repaired and built up 20 inches higher. The apron sheeting was then replaced, and, together with the adjacent course of sheeting, was securely bolted down. On account of the late date at which the low-water season came and its short duration, further repairs could not be made; and the work of replacing and bolting down the upper courses of sheeting and purlins beneath was postponed until a more favorable time. The comb of the dam was thus left, and still remains, elevated to such a height as to cause pool No. 8, during low water, to stand about 1 foot above normal pool level. At the close of repairs, and as a protection to the apron of the dam against the reactionary current, 976 cubic yards of riprap stone were piled against the lower face of the dam up to the sheeting of the apron. Upon recent examination, these stones

were found to have remained in place during the freshets of the past winter and spring, and this scheme for the protection of the terminal wall seems, so far, to have accomplished all that could be desired. At the close of the fiscal year the dam shows no sign of further injury. It has been observed that the water flows from the raised portion of the apron more readily and with much less commotion than before repairs were made.

Valve stems stiffened.—The stems of the two emptying valves were stiffened during the past year, and those of the filling valves during the year before. All the valves now have rigid stems and can be closed under pressure, a condition that greatly improves the efficiency of the lock.

LOCK AND DAM NO. 9, HOARD ROCKS.

Repair of apron of dam.—The injury to the apron of Dam No. 9 extended for a distance of 293 feet, covering the west end and middle portion, and began with a lift of the apron sheeting and the stringers to which the sheeting was bolted. Subsequently, the sheeting for a distance of about 130 feet and a section of the crib apron 40 feet long were entirely carried away. The eastern end, or that part next to the lock, remained unharmed.

The damage has been fully repaired and additional anchorage and protection given by spiking to the face of the apron, 3-inch plank, placed vertically and 3 inches apart. The new crib work, built in place of that part which had been carried away, was also securely fastened to the old crib work and to the masonry of the dam by means of chains. At this, the end of the fiscal year, the apron appears to be in a substantial condition.

Other repairs.—The stem of the Stoney Valve was stiffened in the month of January, during the short suspension of navigation on account of ice and high water; some underpinning was given the abutment on the west side of the river, and the dry retaining wall below the lock was repaired and raised. This wall has a rough quarry face, and could be much improved by a timber sheathing.

In 1881 the dam at Lock No. 9 was lowered 2 feet on account of the difficulty of sustaining the excessive pressure brought against this dam as long as No. 8 was unbuilt. As that dam has since been finished, it is desirable that Dam No. 9 be restored to its original height, especially in view of the fact that the water in Pool No. 9 is scant at some places. After the coping was removed, the top of the dam, with the exception of a section 20 feet long next to the abutment, was finished off with Portland cement concrete, which has stood very well; but of the 20 feet not thus protected, the top course of masonry during the past year sustained some slight injury which has been temporarily repaired with timber.

ENCROACHMENTS.

The harbor of Pittsburg has been under the immediate supervision of Mr. J. W. Arras, assistant engineer. The following is an extract from his report:

At the close of the fiscal year 1891 two railroad companies and six large manufacturing concerns, located between lock and dam No. 2 and the mouth of the river, had been prevented, either by injunction or the filing of a stipulation with the court, from encroaching further on the stream, and bills in equity praying for the issuing of injunctions filed in a number of other cases.

At the hearings these promptly filed stipulations agreeing to deposit no material in the river, pending the establishment of harbor lines at Pittsburg.

Many complaints were received charging persons with depositing refuse materials into the river. In all such cases investigations were made, and wherever there seemed to be just cause for the complaint, the persons offending were notified to stop. This action usually had the desired effect, and in only a few instances was it necessary to procure the assistance of the United States attorney.

In the case of one, who ran a garbage dump at the Birmingham Bridge, from which all manner of waste material was permitted to be placed in the channel of the river, and which was the cause of frequent complaint by navigators, notice was given him to stop his illegal operations, but, failing to do so, he was arrested; being placed on trial, he was convicted of violating sections 6 and 10 of the river and harbor act of 1890. An effort is being made to procure a new trial for him.

As soon as convicted of placing refuse material into the channel, he removed the boat from which the dumping was done, which itself was a very serious obstruction to navigation.

The frequent proceedings which have been instituted to enforce the law of 1890

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against persons encroaching on the river have had the effect of causing almost an entire suspension of encroachments in general. Notwithstanding this, however, a constant vigilance is necessary in order to maintain a permanent obedience to the law.

Estimate for fiscal year ending June 30, 1893.

Dredging spoil bank to destroy a dangerous eddy and to back Dam No. 9	$2,500
Dredging material below lock to back Dam No. 8	2,500
Salaries and wages	5,700
Traveling expenses	500
Rent, fuel, light, and stationery	200
Removing snags and other obstructions	1,000
Lock No. 8, repairs, etc.:	
Valves in turbine races	800
Plastering turbine races	1,000
Bank protection below lock	1,500
Rebuilding storage shed	1,000
Painting lock gates and buildings	400
General repairs to operating machinery	800
Lock No. 9, repairs, etc.:	
Rebuilding lock-keeper's dwellings, carried away by flood, 1888	6,000
Step on apron of dam	3,500
Sheathing guide wall	2,000
Raising dam	3,000
Rebuilding storage shed	1,000
Contingencies	3,000
Total	36,400

Detailed statement of expenses incurred in operating and care of locks and dams on the Monongahela River during the fiscal year ending June 30, 1892.

Month.	Operating expenses.				Repairs.				Tools and appliances.	Grand total.
	Salaries.	Supplies.	Miscellaneous expenses.	Total.	Hire of boats and barges.	Labor.	Material.	Total.		
1891.										
July	$565.04	.....	$11.00	$576.04	.....	.....	$488.91	$488.91	.....	$1,064.95
August	622.91	$21.00	84.80	728.71	$416.00	$538.67	595.34	1,550.01	$858.42	3,137.14
September	540.00	31.65	31.40	603.05	410.00	1,830.42	1,279.51	3,519.93	113.60	4,236.58
October	395.00	13.17	20.89	429.06	322.00	2,881.57	2,649.98	5,853.55	174.77	6,457.38
November	552.95	.....	32.45	585.40	.....	333.34	1,484.34	1,817.68	29.98	2,433.06
December	488.50	.....	.....	488.50	.....	.....	.....	.....	.....	488.50
1892.										
January	496.15	.....	8.00	504.15	.....	.....	.....	.....	.....	504.15
February	486.80	.....	28.32	515.12	.....	.....	.....	.....	.....	515.12
March	415.00	1.55	16.00	432.55	10.00	.....	.....	10.00	.....	442.55
April	488.50	2.10	17.04	507.64	.....	.....	.47	.47	.....	508.11
May	673.90	4.78	.....	678.68	.....	.....	45.62	45.62	11.00	735.30
June	723.78	1.60	.....	725.38	.....	.....	251.21	251.21	2.90	979.49
Total	6,448.53	75.85	249.90	6,774.28	1,158.00	5,584.00	6,795.38	13,537.38	1,190.67	21,502.33

Commercial statistics are attached to the report for the improvment of Monongahela River.

D D 7.

PURCHASE OF LOCK AND DAM NO. 7, MONONGAHELA RIVER.

At the close of the last fiscal year the case of the United States *vs.* The Monongahela Navigation Company, in the matter of the condemnation of Lock and Dam No. 7, was set to be heard on appeal at the November term of the circuit court of the United States for the western district of Pennsylvania.

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At that term Judge Acheson fixed the sum of $209,000 as the value of Lock and Dam No. 7, which is the same sum, in round numbers, that was set by the viewers. Sundry legal questions connected with the case having been decided in favor of the United States, the Navigation Company took an appeal to the Supreme Court of the United States, where the matter is now pending. It has been advanced, however, on the argument list to October next.

Money statement.

July 1, 1891, balance unexpended	$161,835.45
July 1, 1892, balance unexpended	161,835.45

D D 8.

PURCHASE OF LOCK AND DAM NO. 6, MONONGAHELA RIVER.

The river and harbor act of September 19, 1890, contains the following item:

That whenever the proceedings commenced by the United States against the Monongahela Navigation Company, a corporation organized under the laws of Pennsylvania, to condemn Lock and Dam No. 7, constituting a part of the improvement in water communication in the Monongahela River between Pittsburg, in the State of Pennsylvania, and a point at or near Morgantown, in the State of West Virginia, shall be finally determined, and the United States shall have acquired the title to said Lock and Dam No. 7 and its appurtenances, the Secretary of War be, and he is hereby, authorized and directed to negotiate for and purchase, at a cost not to exceed $162,000, Lock and Dam No. 6 and its appurtenances, of the Monongahela Navigation Company, also constituting a part of said improvement. And the sum of $162,000, or so much thereof as may be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated, for consummating said purchase, the same to be paid on the warrant of the Secretary of War upon full and absolute conveyance to the United States of the said Lock and Dam No. 6 and its appurtenances of the said Monongahela Navigation Company.

In the event of the inability of the Secretary of War to make voluntary purchase of said Lock and Dam No. 6 and its appurtenances for said sum of $162,000 or a less sum, then the Secretary of War is hereby authorized and directed to institute and carry to completion proceedings for the condemnation of said Lock and Dam No. 6 and its appurtenances, said condemnation proceedings to be as prescribed and regulated by the provisions of the general railroad law of Pennsylvania, approved February 19, 1849, and its supplements, except that the United States shall not be required to give any bond, and except that jurisdiction of said proceedings is hereby given to the circuit court of the United States for the western district of Pennsylvania with right of appeal by either party to the Supreme Court of the United States: *Provided*, That in estimating the sum to be paid by the United States, the franchise of said corporation to collect tolls shall not be considered or estimated; and the sum of $5,000, or so much thereof as may be necessary, is hereby appropriated out of any moneys in the Treasury not otherwise appropriated, to pay the necessary costs of said condemnation proceedings; and upon final judgment being entered therein the Secretary of War, if in his opinion the judgment is reasonable, is hereby authorized and directed to draw his warrant on the Treasury for the amount of said judgment and costs, and said amount for the payment thereof is hereby appropriated out of any moneys in the Treasury not otherwise appropriated. And when said Lock and Dam No. 6 and its appurtenances shall have been acquired by the United States, whether by purchase or condemnation, the Secretary of War shall take charge thereof, and the same shall thereafter be subject to the provisions of section 4 of an act entitled "An act making appropriations for the construction, repair, and preservation for certain public works on rivers and harbors, and for other purposes," approved July 5, 1884.

As action under these instructions can not be initiated until the United States shall have acquired the title to Lock and Dam No. 7, it is only necessary to state that the paragraphs which are quoted above are yet in abeyance.

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Money statement.

July 1, 1891, balance unexpended	$167,000.00
July 1, 1892, balance unexpended	167,000.00

D D 9.

IMPROVEMENT OF CHEAT RIVER, WEST VIRGINIA.

The river and harbor act of September 19, 1890, contained an appropriation of $13,000 for the improvement of Cheat River. This is the only appropriation ever made for this river.

The object of the improvement was to make this river navigable for loose logs, so as to bring out the immense supplies of timber found in the virgin forests on the Cheat River and its tributaries. In its natural condition it was impossible to bring down rafts, and a large percentage of the loose logs was stranded among the rocks and left there to decay.

The rough part of the river commences about 3 miles below Rowlesburg and terminates at Beaver Hole, 16 miles above the mouth, where the river emerges from Laurel Ridge. The total length of difficult river is 30 miles.

The original project for the improvement of the river was the removal of such rock obstructions as interfered with the free passage of logs on a 6 or 8 foot stage of water. At the suggestion of lumbermen and others interested in the improvement of this river, an additional project was adopted of making a low-water channel from near Rowlesburg down the river in which logs could be floated on a rise of from 2 to 3 feet.

This work has been under the immediate supervision of Mr. Philip Golay, Assistant Engineer.

REPORT OF OPERATIONS FOR THE FISCAL YEAR.

(EXTRACT FROM REPORT OF MR. PHILIP GOLAY.)

Work was begun in November, 1890, suspended in January, 1891, on account of bad weather, resumed in the following April, and closed January 9, 1892, at which time the amount of the appropriation ($13,000) was found to be exhausted.

Prior to the latter part of September, 1891, the work was prosecuted with a view of removing such rock obstructions as interfered with the passage of loose logs when rises of from 6 to 8 feet occur. To this end 10,058 cubic yards of rock obstruction were blasted and the river was put in fair condition as far down as Green Island, 20¼ miles below Rowlesburg.

During the month of September, 1891, lumbermen urged that a low-water channel as they termed it, be made. About this time, also, Col. Merrill paid a visit to the Monongahela River and Morgantown office, and after discussing the subject with various parties interested in the improvement of Cheat River, he directed that the plan of the lumbermen be adopted. Accordingly about the latter part of September, 1891, the force of workmen with tools and material were sent again to the upper end of the troublesome part of the river, about 2 miles below Rowlesburg, and working down stream, blasted in the low-water channel 3,789 cubic yards of rock, clearing the channel so that logs can be driven on from 2 to 3 feet rises down to a point 8 miles below Rowlesburg. The total number of cubic yards of rock obstruction blasted and removed, or leveled down, is 13,847.

An additional sum could be advantageously expended in removing more rock obstructions—3,000 cubic yards between Pringle Run and Green Island, mostly in low-water channel, and 7,000 cubic yards of channel and shore rocks, between Green Island and Forge Island, making a total of 10,000 cubic yards of rock obstruction yet necessary to be blasted. Guide cribs should also be constructed at the heads of

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some low bars to keep logs in the channel. For the building of these guide cribs and to finish blasting rock obstructions the additional sum of $20,000 is needed.

At the close of work, January 9, 1892, all the Cheat River property was transported to the Monongahela River, where there is ample storage room.

Money statement.

July 1, 1891, balance unexpended	$7,891.85
June 30, 1892, amount expended during fiscal year	7,884.35
July 1, 1892, balance unexpended	7.50
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	20,000.00

Timber product of Cheat River for twenty years ending December 31, 1891.

Date.	Received by mills at mouth of river.	Passed on to points below.	Total.	Date.	Received by mills at mouth of river.	Passed on to points below.	Total.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
1872	35.00	11.67	46.67	1882	428.33	142.78	571.11
1873	385.00	128.33	513.33	1883	916.67	305.56	1,222.23
1874	440.83	146.95	587.78	1884	540.83	180.28	721.11
1875	340.83	113.61	454.44	1885	5,540.83	1,846.94	7,387.77
1876	187.17	63.06	250.23	1886	4,527.50	1,509.17	6,036.67
1877	173.83	57.95	231.78	1887	6,035.83	2,011.94	8,047.77
1878	186.67	62.22	248.89	1888	3,612.50	1,204.17	4,816.67
1879	233.33	77.78	311.11	1889	5,625.00	1,875.00	7,500.00
1880	425.00	141.67	566.67	1890	3,741.17	1,247.06	4,988.23
1881	383.33	127.78	511.11	1891	13,310.10	665.51	13,975.61

D D 10.

IMPROVEMENT OF ALLEGHENY RIVER, PENNSYLVANIA.

The following is a statement of the amount and date of all appropriations for this river:

March 3, 1879	$10,000	August 5, 1886	$30,000
June 14, 1880	20,000	August 11, 1888	25,000
March 3, 1881	25,000	September 19, 1890	20,000
August 2, 1882	15,000		
July 5, 1884	35,000	Total	180,000

The approved project for the improvement of this river was the removal of obstructions from the channel, and the construction of low dams to close duplicate channels, and of dikes to contract the waterway where the river is too wide. The amount expended on this project to the end of last fiscal year was $161,400.12.

There remained available at the beginning of the fiscal year $18,599.88.

This work has been under the immediate supervision of Mr. J. W. Arras, assistant engineer.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM REPORT OF MR. J. W. ARRAS.)

The latter part of the season of 1891 was favorable to a prosecution of improvements on the Allegheny River, and all of the work under way, or contemplated at the close of the last fiscal year, except the removal of the bar at Pithole Ripple, was completed.

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LOW DAMS AND DIKES.

Log chute at Corydon, Pa., 209 miles above Pittsburg.—During the past winter an ice gorge damaged part of the mill dam across the river at Corydon, thereby injuring some of the sheeting of the log chute, which is built at the lower side of it. It is thought the repairs can readily be made at a cost not exceeding $70.

Dam at Cornplanter Island, 204 miles above Pittsburg.—This dam, which at the close of the last fiscal year had been nearly finished, was completed. Its length is 334 feet, width at base 18 feet, and height above low water 3 feet. An abutment for the protection of the roots of the dam was built at each end to the height of the bank.

The total quantities of material used in the construction of the dam and abutments were as follows:

Oak lumber	feet, B. M..	34,636
Hemlock lumber	do....	23,632
Drift bolts	pounds..	2,991
Stone	cubic yards..	895
Excavation made	do....	240

The cost of labor and materials in the entire work was $2,503.05.

This dam was designed to confine the water theretofore wasting down the island chute, thereby reducing the navigable depth of the water on the very shallow bar nearly opposite to the channel on the right. No actual soundings were made, but the observations and experience of timber and lumbermen show beyond a doubt that there has been an increase of more than a foot in the depth of the water at a 3-foot stage. Navigators speak in terms of highest praise of this improvement, and point to the fact that since its completion the shipments from above that point have doubled. The dam at present is in good condition.

Dam at Hickory, 157 miles above Pittsburg.—The dam designed to improve Hickory Ripple was originally located across the left or main channel, at the head of Greens Island, the intention having been to make the right chute the channel for navigation. When everything was in readiness for commencing its construction serious objections were offered by some local timber men, who claimed that the erection of a dam closing the left chute at the head of Greens Island would greatly impair the usefulness of their timber landings on that side of the river opposite the foot of the island. To obviate the possibility of damaging the landings a survey above and below the head of Greens Island was made, and the location of the dam changed to a point about a mile farther down, and so as to cross the right chute at the head of the lower island. The dam here was designed to confine the water below a 3-foot stage, about three-fourths of which drifted into the right chute at this point, into the left or original channel, and to cut out the channel bar opposite. Work was commenced on its construction about August 1, and the structure completed on October 14. The dam is built on a sharp curve, running from the right bank around the head of the island. Its length is 730 feet, width at base 18 feet, and height from 6 to 7 feet; the elevation of a 3-foot stage of water. An abutment 40 feet long at the root and one at the head of the island 50 feet long were built, and the outer side of the island well protected with heavy riprap stone. The structure is reported as being in good condition.

In the construction of this work the following quantities of material were expended, viz:

Oak lumber	feet, B. M..	68,526
Hemlock lumber	do....	56,684
Drift bolts	pounds..	8,022
Spikes	do....	285
Stone	cubic yards..	2,170
Excavation made	do....	180

The cost of material and labor was $5,623.49.

This improvement also has been productive of excellent results, and whereas Hickory Ripple had always been dreaded on account of its shallowness, caused by the water spreading over so much territory, now, according to the reports of navigators, the difficulties and dangers heretofore existing have entirely disappeared.

Dam at Pithole, 143 miles above Pittsburg.—The construction of this dam had been commenced at the close of the last fiscal year. Under favorable conditions the work was pushed along rapidly and the structure finished in September. It extends from the left bank down to the high bar, formerly Pithole Island, a distance of 1,132 feet. Its width at base is 18 feet, and its height the level of a 3-foot stage. An abutment 40 feet long and 10 feet high was built at the root to protect the bank.

The object of this improvement was to stop the waste of water down the left chute, which almost equaled the flow down the right, and thus increase the navigable depth of the water in the channel. This has been accomplished, fully a foot

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in depth having been added to the channel at a 3-foot stage. No damage has occurred to this work since its completion.

The following is a statement of the quantities of material expended in the construction of the dam and abutment:

Oak lumber	feet, B. M.	104,554
Hemlock lumber	do	84,090
Drift bolts	pounds	11,300
Spikes	do	325
Stone	cubic yards	2,490
Excavation made	do	860

The cost of materials and labor was $8,075.76.

Dike at Red Bank, 64 miles above Pittsburg.—Although one of the most extensive ice gorges seen in many years in the Allegheny swept over this dike in February of the past winter, yet the damage to it is slight, not exceeding the displacement of a few squares of paving. It is estimated that $40 will make the repairs.

Dam at Nicholson Island, 37 miles above Pittsburg.—This work was put in good repair in the season of 1891 by replacing about a square of paving which had washed out. During the past winter the Parker ice gorge damaged some of the paving. The necessary repairs, it is estimated, can be made for $30.

Dam at Sixmile Island.—This structure has remained in good condition.

REMOVAL OF OBSTRUCTIONS.

Removal of bar at foot of Pithole Ripple.—This work was commenced but not carried to completion, owing to the lateness of the season; 500 cubic yards of rock were removed.

Removal of rock and other obstructions below Kittanning.—A number of dangerous rocks and snags had made their appearance on the lower portion of the river, and in October a small force was put to work removing them. The party operated from Kittanning to Pittsburg, a distance of 45 miles, making the following removals of obstructions, viz:

Locality.	Rock.	Snags.
	Cu. yds.	
Kittanning	40	.....
Cogleys Island	50	.....
Head of Ross Island	125	3
Nicholsons Island	205	.....
White Rock	10	.....
Murphys Island	.....	6
Tarentum Island	50	.....
Bull Creek	75	1
Logans Landing	6	.....
Fourteenmile Island	60	1
Total	621	11

ENCROACHMENTS.

At the close of the last fiscal year most of the leading parties encroaching on the navigable capacity of the river had been restrained, either by injunction, or by stipulations in which they agreed to stop depositing waste material over the banks, pending the establishment of harbor lines. During the year, however, navigators had frequent occasion to report parties engaged in filling material into the stream. These cases were promptly investigated, and the guilty parties were notified to stop their unlawful practices, which in every case they did, thus obviating the necessity of taking legal action.

Navigators have heretofore frequently experienced great inconvenience on account of huge piles of coarse gravel formed in the harbor by parties digging sand from the river bed, and last season the operations of one company became so objectionable that an information was made against them and their employés. At the hearing they were indicted and held for trial at court. Subsequently they removed the piles of gravel. Members and employés of a dredge company were prosecuted for obstructing the channel at the Union Bridge. After being indicted they removed all the material put in. These cases have not yet been tried.

The removal of large quantities of rocks, snags, and other obstructions from the bed of the river, and the erection of low dams and dikes, shutting off duplicate chutes and contracting the channel where spread over large areas, have resulted in great good to the general trade, and much more work of the same nature remains to be

done for the relief and safety of navigation. The most important improvement that can be made on the Allegheny, however, and which should receive serious consideration, is the extension of slack water, at least as far up as Soda Works, 20 miles above Pittsburg. This part of the Allegheny Valley is rapidly building up with mills and industrial establishments of other kinds, which demand and deserve facilities for cheap and permanent transportation.

Money statement.

July 1, 1891, balance unexpended	$18,599.88
June 30, 1892, amount expended during fiscal year	16,977.73
July 1, 1892, balance unexpended	1,622.15
July 1, 1892, outstanding liabilities	163.00
July 1, 1892, balance available	1,459.15
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	26,459.15
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	25,000.00

COMMERCE.

It has never been possible to procure complete statistics of the commerce of the Allegheny River, owing to its scattered condition and the fact that there is no record of it kept anywhere. It is, therefore, impossible to state whether there has or has not been an increase in the tonnage over that of the previous year. The local harbor tonnage exceeds that of 1890 by 361,023 tons, most of which is attributable to an increase in the trade.

The following is a statement of the principal commercial movements on the river during the calendar year 1891:

Articles.	Quantity.	Articles.	Quantity.
	Tons.		*Tons.*
Barges	2,700	Lath	286
Bark	2,624	Manure	800
Barrels	900	Nitroglycerin	12
Boat bottoms	29,412	Piles	1,896
Brace poles	813	Pit posts	6,223
Cattle and horses	926	Rough lumber	105,959
Check posts	1,510	Sand	84,439
Coal	1,400	Sheep	30
Curbstone	406	Shingles	270
Fire clay	2,700	Stone	36,947
General freight	2,625	Timber	105,245
Gravel	12,453		
Hay	150	Total	400,726

Passengers carried, 5,650.

In addition to the above, the following is a statement of the principal commercial movements in the Allegheny Harbor at Pittsburg:

Articles.	Quantity.	Articles.	Quantity.
	Tons.		*Tons.*
Cars, loaded	362,342	Oil	11,040
Cars, empty	77,916	Railroad ties	14,825
Clinker	1,500	Sand	172,040
Coal	189,282	Staves	9,376
Gas pipe	5,640	Vegetables	360
Gravel	33,845		
Fire brick	1,059	Total	896,095
Manure	16,870		

Passengers carried, 59,000.

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D D 11.

DAM AT HERR ISLAND, ALLEGHENY RIVER, NEAR PITTSBURG, PENNSYLVANIA.

The following is a statement of the amount and date of all appropriations for this work:

August 5, 1886	$37,500
August 11, 1888	35,000
September 19, 1890	35,000
Total	107,500

The land required on both banks of the river was purchased. The authorities of Allegheny City, to whom the land on the right bank belonged, sold it for the nominal consideration of $1, on condition that the dam should be a movable one. A petition to the same effect was likewise received from the authorities of the city of Pittsburg, from the Pittsburg Chamber of Commerce, and from the Engineers' Society of Western Pennsylvania. In all the petitions the reason alleged for desiring that the dam be a movable one was the fear that the height of floods in the Allegheny River would be increased by a fixed dam.

The question of the proposed change was referred to the Secretary of War by the Chief of Engineers, and on September 29, 1890, it was ordered that the dam at Herr Island be made a movable one. This change in design necessitated a corresponding change in the estimated cost of the work; the estimate for the present design is $600,000.

It was supposed that after this action there would be no further cause for delay, but a number of riparian owners on the left or Pittsburg side of the river, to whom no allowance for damages had been made, for the reason that the proposed lock was to be outside of the high-water line, brought suit in the circuit court of the United States for compensation. The case was placed in the hands of the United States attorney for the western district of Pennsylvania, where it still remains.

The Davis Island Dam pool gives permanent navigation on about 2 miles of the lower portion of the Allegheny, and during the calendar year 1891 the local commercial movements on that part of the river amounted to more than 830,000 tons.

The legal questions which stand in the way of the commencement of this important work should be settled, and it is hoped that some action will be taken at an early day by those having the matter in charge.

This work has been under the immediate supervision of Mr. J. W. Arras, Assistant Engineer.

Money statement.

July 1, 1891, balance unexpended	$70,648.23
June 30, 1892, amount expended during fiscal year	1,951.38
July 1, 1892, balance unexpended	68,696.85
Amount appropriated by act approved July 13, 1892	40,000.00
Amount available for fiscal year ending June 30, 1893	108,696.85
Amount (estimated) required for completion of existing project	484,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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D D 12.

ICE HARBOR AT MOUTH OF MUSKINGUM RIVER, OHIO.

The ice harbor is the lower pool of the Muskingum River, which has been created by the slack-water dam at Marietta, and the object of the work under consideration is to build a passway through this dam, of such size as will permit Ohio River packets and coal fleets to take refuge from ice in this pool. The passway in question consists of a large lock, which, owing to the local conditions controlling the only available site, was built with independent axes of entrance and exit, the angle between these axes being 11° 15′. This involved the necessity of widening the lock chamber at both ends so as to permit boats to change direction while in the lock. The plan of the lock chamber is therefore somewhat like an hourglass, the lock being narrowest in the middle. The maximum rectangle which can be passed through the lock has a length of 365 feet and a width of 56 feet. The work has been in progress since 1880, but has been kept back by inadequate appropriations and the occasional absence of any appropriation. The lock is now nearly finished and is in use.

The following is a statement of the amount and date of all appropriations for the work:

March 3, 1879	$30,000	August 5, 1886	$37,500
June 14, 1880	50,000	August 11, 1888	60,000
March 3, 1881	30,000	September 19, 1890	30,000
August 2, 1882	40,000		
July 5, 1884	50,000	Total	327,500

This work was under the immediate supervision of Lieut. Cassius E. Gillette, Corps of Engineers, U. S. Army, until April 20, 1892. Since that time Mr. Edmund Moeser, Assistant Engineer, has had immediate supervision of the work.

OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM REPORT OF MR. EDMUND MOESER.)

At the beginning of the year the masonry of the river wall was complete; the land wall was complete with the exception of 155 feet, which was 12 feet above the lower miter sill. Work was carried on without interruption; the masonry of the land wall was finished, being about 1,100 yards, the hollow quoins set, and the lower gates built and placed in position.

A contract was made with the Griffith and Wedge Company, Zanesville, Ohio, for the iron work, consisting of mud valves, turbine culvert valves, head gates for mill race, machinery for operating lower gates, and all machinery for operating valves. The under-water iron work was all placed as soon as finished, so that the lock was ready for use December 1, 1891.

Two thousand two hundred and eighty-seven cubic yards of mud was taken from the lock chamber and filled into the old mill race on the lock lot.

The lock will not be available for Ohio River boats until a draw is placed in the Baltimore and Ohio Southwestern Railroad Bridge just below it. No move has been made by the railroad company towards changing the bridge.

Money statement.

July 1, 1891, balance unexpended	$20,114.29
June 30, 1892, amount expended during fiscal year	20,063.51
July 1, 1892, balance unexpended	50.78

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Abstract of proposals for constructing machinery for Ice Harbor Lock at Marietta, Ohio, opened August 20, 1891.

No.	Name and address of bidder.	Including middle gates.				Total.*	Excluding middle gates.				Total.*
		Wrought iron, per pound.	Cast iron, per pound.	Steel, per pound.	Brass, per pound.		Wrought iron, per pound.	Cast iron, per pound.	Steel, per pound.	Brass, per pound.	
		Cts.	Cts.	Cts.			Cts.	Cts.			
1	The Griffith & Wedge Co., Zanesville, Ohio ..	6.50	5.50	7.00	$0.35	$4,257.27	6.50	5.50	$0.10	$0.35	$2,706.64
2	Lambert Bros. & Co., Ironton, Ohio.....	6.37	7.30	10.00	.50	5,062.59	6.37	7.30	.15	.50	3,026.54
3	The Blandy Machine Co., Zanesville, Ohio ..	8.00	8.00	12.50	.40	5,947.23	8.00	10.00	.20	.40	3,969.12
4	The Hall Steam Pump Co., Pittsburg, Pa	9.50	10.75	8.75	.25	6,987.52	9.50	10.75	.11	.25	4,474.85
5	The I. & E. Greenwald Co., Cincinnati, Ohio ..	13.00	7.00	13.00	.30	7,001.92	8.50	7.50	.08½	.30	3,566.91
6	Thos. Carlin's Sons, Allegheny, Pa.....	10.73	9.80	14.68	2.60	7,539.25	10.93	10.90	2.60	2.60	4,921.06
7	Scaife Foundry and Machine Co., Pittsburg, Pa	13.50	10.50	11.50	.56	8,221.43	.13	13.50	.36	.56	5,879.99

* Including extra charge for patterns, $25.

Contract awarded the Griffith & Wedge Co., and executed August 29, 1891.

Abstract of contracts for material for constructing Ice Harbor Lock at mouth of Muskingum River, made during the fiscal year ending June 30, 1892.

Contractor.	Improvement.	Date.	To expire—
The Griffith & Wedge Co.....	Metal work for Ice Harbor Lock.....	Aug. 29, 1891	Dec. 15, 1891

Commercial statistics are attached to the report for operating and care of locks and dams on the Muskingum River.

D D 13.

OPERATING AND CARE OF ICE HARBOR LOCK AT MOUTH OF MUSKINGUM RIVER, OHIO.

An allotment of $1,200 was made December 10, 1891, for the operating and care of this lock.

The work was under the immediate supervision of Lieut. Cassius E. Gillette, Corps of Engineers, U. S. Army, until April 20, 1892. Since that time Mr. Edmund Moeser, assistant engineer, has had immediate supervision of the work.

The lock was ready for use December 1, 1891.

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OPERATIONS FOR THE FISCAL YEAR.

(EXTRACT FROM THE REPORT OF MR. EDMUND MOESER.)

Expenditures were for lock-keepers and assistant, materials for repair of gates, for labor in placing machinery for operating gates and for dredging entrance to lock and removing pieces of coffers.

Detailed statement of expenses incurred during the fiscal year ending June 30, 1892, out of the appropriation for operating and care of canals and other works of navigation, in operating and keeping in repair the Muskingum Ice Harbor Lock, Ohio.

Month.	Salaries lock-keeper and assistant.	Labor.	Supplies.	Miscellaneous.	Dredging.		Total.
					Salaries.	Towboat.	
December		$62.25					$62.25
January		14.70					14.70
February			$25.00				25.00
March		24.45	2.00				26.45
April	$55.00						55.00
May	105.00		14.38	$4.80	$157.65	$180.00	461.83
June	105.00	102.75					207.75
Total	265.00	204.15	41.38	4.80	157.65	180.00	852.98

Commercial statistics are attached to the report for operating and care of locks and dams on the Muskingum River.

D D 14.

IMPROVEMENT OF MUSKINGUM RIVER, OHIO.

This report is limited to work carried on under the appropriation of August 11, 1888, for the construction of a lock at Taylorsville and the reconstruction of the lock at Zanesville, Ohio, of $102,000.

This work was under the immediate supervision of Lieut. Cassius E. Gillette, Corps of Engineers, U. S. Army, until April 20, 1892. Since that time Mr. Edmund Moeser, assistant engineer, has had immediate supervision of the work.

OPERATIONS FOR THE FISCAL YEAR.

(EXTRACT FROM THE REPORT OF MR. EDMUND MOESER.)

The work of opening out the channel below new Lock No. 9 was completed. There is now a well-defined channel running from the lower end of the new lock on the right side of the river, downstream, and finally across the river to near the mouth of Salt Creek, 2,000 feet below new Lock No. 9. The excavation extended over a distance of 800 feet. The bottom of this excavation is on a level 2 feet below the top of the lower miter sill of the lock. The remainder of the distance to Salt Creek will require some dredging.

During the year 13,443 cubic yards of rock and 10,062 cubic yards of earth were excavated, at a cost of 80 cents per yard for rock excavation and 31¼ cents per yard for earth excavation.

The coping of the new lock was repointed, balanced counter weights were added to the machinery for operating the cylindrical valves, and the lower gates were framed but are not yet placed.

The balance of the money expended at this place during the year was for plant and material which are on hand and which are to be used in the construction of a guiding crib at the head of the new lock.

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No work was done under that part of the appropriation relating to the reconstruction of the lock at Zanesville, Ohio.

It is proposed to make a survey of the vicinity to ascertain the feasibility and propriety of rebuilding the lock in another location. The existing lock, with two lifts, is in a very dilapidated condition, but can be made to serve for a time by repairing the gates.

Commercial statistics are attached to the report for operating and care of locks and dams on Muskingum River.

Money statement.

July 1, 1891, balance unexpended	$35,301.24
June 30, 1892, amount expended during fiscal year	19,783.26
July 1, 1892, balance unexpended	15,517.98
July 1, 1892, outstanding liabilities	370.71
July 1, 1892, balance available	15,147.27

D D 15.

OPERATING AND CARE OF LOCKS AND DAMS ON MUSKINGUM RIVER, OHIO.

The following is a statement of the amount and date of all appropriations and allotments for this work:

August 5, 1886, appropriated	$20,000.00	July 8, 1891, allotted	$155,200.00
July 21, 1887, allotted	190,000.00	November 10, 1891, allotted	39,980.00
August 13, 1888, allotted	177,623.00	November 25, 1891, allotted	1,200.00
July 1, 1889, allotted	232,080.00	January 5, 1891, allotted	12,241.54
July 19, 1890, allotted	195,665.00		
June 1, 1891, allotted	20,000.00	Total	1,043,989.54

The season of 1891 was very favorable for work. The reconstruction of locks Nos. 6 and 7, in progress at the beginning of the fiscal year, was completed. The reconstruction of locks Nos. 2 and 5 was completed so far as to admit of their use.

Repairs of dams Nos. 1, 6, and 8 were completed, and minor repairs were made to dams Nos. 2, 3, 4, 5, 7, 9, and 10.

In reconstructing the locks all miter sills, where the bottom would permit, were built of masonry and the tops placed at equal depths below their respective pools. Guards were made uniform, so that all locks will be submerged at about the same time, and errors in width and length of locks were corrected. The placing of the sills at a uniform depth has added from 6 inches to 3 feet to the navigable depth of the river; a navigable depth of 6 feet can now be maintained. By raising guards of locks, the height of the navigable high-water line has been increased 3 feet.

Through navigation, which had been interrupted by the closing of the locks for repairs in May, 1889, was resumed with the opening of Lock No. 5, May 6, 1892.

This work was under the immediate supervision of Lieut. Cassius E. Gillette, Corps of Engineers, U. S. Army, until April 20. Since that time Mr. Edmund Moeser, assistant engineer, has had immediate supervision of the work.

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OPERATIONS DURING THE FISCAL YEAR.

(EXTRACT FROM THE REPORT OF MR. EDMUND MOESER, ASSISTANT ENGINEER.)

LOCKS AND DAMS.

Lock and Dam No. 1, Marietta.—The work of rebuilding this dam was in progress July 1, 1891, but was interrupted by a rise in the Ohio River during the month. Work was resumed in August and the dam completed during the month of October. The dam is built on the slope type, with slope of 1 on 4 and a 10-foot horizontal apron at its foot. The total length of the dam is 526 feet.

The remainder of the river wall of the old abandoned lock, No. 1, was torn out, and the land wall was completed, all but the coping, for use as an abutment to Dam No. 1.

A new race, leading to the mill below the Ice Harbor Lock, was excavated back of the land wall of the lock and the material thus excavated used in filling the old raceway.

A small amount of stone fill and about 100 feet of gravel backing is all that is required to complete this dam.

Lock and Dam No. 2, Devols.—The repairs at this place were limited to such work as could be done without making it last longer than the work at other points and thereby delay the opening of through navigation. The project for reconstruction included the removal of the old foundation timbers under floor of lock chamber, as the lock was said to be founded on rock, making the lower miter sill of stone, and the insertion of mud valves in walls at lower gate recess. After the cofferdams were finished and unwatered, investigation developed the fact that the lock was not on rock, but stands on a tough red clay overlying a red rock. Owing to the lateness of the season a change of plan was necessary; the lower miter sill was built of timber and the mud valves were omitted. The lock was closed for repairs July 20, 1891, and reopened to navigation January 22, 1892.

The following was the work accomplished: Built new upper and lower gates and miter sills; six slide valves were placed in the two lower gates. Put in upper miter wall with filling culverts. Inserted cylindrical filling valves in head of old lock walls. Raised 117 feet of lock wall 3.2 feet, to make guard of lock standard height. Made general repairs to face of old lock walls and stopped all leaks with concrete. Cleaned out mud and filled spaces between old foundation timbers with concrete. Relaid timber floor of lock chamber. A crib breakwater, 9 feet by 9 feet by 180 feet, was put on the bank below the lock in order to break the eddy caused by dam and lock wall.

Made repairs to dam. The lower apron of the dam had raised, letting out the stone filling; the apron was forced back into place and fastened down with anchor bolts 18 feet long. The bolts penetrate the rock underlying the soft foundation of the dam for a distance of 6 and 7 feet. The dam was refilled with stone where necessary, and the lower apron was sheeted with new timber for a distance of 480 feet.

To complete the repairs at this place the following work remains to be done: To complete raising of lock walls, to build a small guiding crib below the river wall, to put iron cover plates over cylindrical valve machinery, and to put in place lock ladders and new gate-operating machines. About 170 yards of masonry remains to be laid.

Lock and Dam No. 3, Lowell.—This lock has been open to navigation throughout the past year. The section of needle dam across the head of the lock was operated when necessary, and the lower end of the canal kept in good navigable condition. There has not as yet been an opportunity of testing the practicability of keeping the upper end of the canal clear by this method, but a recent sudden flood in Cats Creek, which empties into the canal near the upper end, has put out into the canal a heavy bar of sand and gravel, and a test is to be made on this bar as soon as the river is at a favorable stage. Cover plates, lock ladders, and gate-operating machines are wanted to complete this lock.

Extensive repairs were made to the dam. Two hundred and sixty feet of the lower and second step were rebuilt, and the lower apron was resheeted for its entire length of 848 feet.

The lines of the Government lands at Lowell were surveyed and corner stones set.

Lock and Dam No. 4, Beverly.—The lock was open to navigation during the entire year. The terreplein was raised to top of lock wall and improved by planting with grass. Wooden steps leading to approach of needle dam at head of lock were built. A leak under the lower miter sill, probably caused by a spud of the dredge *Malta* breaking the floor planking, was promptly repaired.

The bank below the dry-stone abutment of spill dam at head of canal was protected by a crib 13 feet wide and 67 feet long.

The embankment at the right abutment was threatened by a leak over the top of

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the crib and through the toe of the riprap face of the fill just above the abutment. The leak was stopped by removing the riprap face and as much of the stone as was possible from the bays of the crib. The bays were then refilled with tight material and the embankment and riprap replaced. No further trouble is apprehended at this place.

The dam was refilled with stone for a distance of 60 feet.

The following work remains to be done at this place: Placing wrought ladders in lock chamber, cover plates over machinery on top of walls and machinery for operating gates; completing the needles for dam at head of lock; driving guiding piles above and below bridge over canal; making fill at head of lock and at head of canal; building crib extension to right abutment.

Lock and Dam No. 5, Duke Chute.—The plans for reconstruction of this lock were similar to those of Lock No. 2. The repairs were limited to such work as could be done without unnecessarily delaying the opening of through navigation. The lock was closed for repairs August 1, 1891, and reopened May 6, 1892. This lock is on rock foundation. The old miter sills were not at a sufficient depth for the requirements of navigation, and the rock in the bottom of the lock chamber was but 4 feet below normal level of lower pool. The following work was done on the lock: Built new upper gates and modified and raised an old pair of gates, built in 1888 to meet the conditions of the reconstructed lock; put in masonry upper and lower miter sills; raised 50 feet of the lock wall to standard height with concrete; built upper miter wall with transverse and filling culverts; thoroughly repaired old lock walls with concrete and dressed back walls to the standard width; excavated the rock bottom in chamber to 1 foot below top of lower miter sill; about 2½ to 3 feet of excavation over the entire chamber was necessary. The rock below the lock was removed by blasting to a depth of 2 feet below the new lower miter sill and over a distance of about 300 feet.

The embankment just above the abutment was raised to a height 8 feet below the top of the abutment and protected by a riprap wall front and back. Part of the front wall next the abutment was laid with cement mortar.

Extensive repairs were made to the dam during the low-water season. The old step dam has been replaced by a standard slope whenever such repairs were necessary, and the entire dam, with the exception of a small piece next the lock, is now a slope of 1 on 4. The design for the repaired portion of this dam is an improvement on that of former slope dams, in that the toe is held down by the weight of stone on the floors placed in every alternate bay and by a system of bolting together the timbers forming the front face of the dam. The 8-inch spaces between the longitudinal timbers are filled with filling pieces, leaving only enough openings for the discharge of water leaking through the dam. The filling pieces prevent the escape of the stone filling and give greater opportunity for bolting.

To complete the repairs at this place it yet remains to raise 310 feet of the lock walls with concrete, to point the old walls, to place cover plates and gate-operating machines upon the lock walls, and to complete repairs to dam by raising low places of the crest to the normal level.

Lock and Dam No. 6, Stockport.—At the beginning of the fiscal year the following was the work yet to be done to complete this place: To build 117 feet 3 inches of the land wall and 125 feet of the river wall, and to entirely rebuild 150 feet of the dam and raise the crest of the remainder 1 foot. The masonry of the lock was finished in August, 1891, and the lock was opened to navigation in October, 1891. Gate-operating machines have since been placed and the lock is now in first-class condition. Lock ladders and cover plates for the valve machinery on top of walls are to be put in place this season.

In the fall of 1891 a long cofferdam was built and a channel excavated through the rock below the lock.

The 150 feet of dam next the lock, which was destroyed in 1890, was replaced by a slope dam, the crest of which is 1 foot higher than that of the old dam. The remainder of this crest is to be raised this season.

A guiding crib 190 feet long was built at the lower end of the land wall; this crib was finished to the level of the lower pool.

Lock and Dam No. 7, McConnelsville.—The reconstruction of this lock was completed in December, 1891, and the lock has been in operation since that date. Since July 1, 1891, 107 feet of the land wall and 93 feet of the river wall were built; the upper miter wall and sill were laid; and the masonry abutments, sill, and foundation of needle dam at head of lock finished; the iron trestles for the needle dam are in place. New gate-operating machines were placed, and the only work which yet remains to entirely complete the lock is the placing of cover plates on top of walls, ladders in prepared recesses of lock chamber, and the wooden needles for needle dam. A small amount of fill at the head of the lock will be necessary to prevent leak around the land wall.

Advantage was taken of the extreme low water during the fall of 1891 to rebuild

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the left abutment of the dam. The old abutment was a timber crib filled with stone. It was only a makeshift, having been built by the State of Ohio in winter and in haste, and there was constant danger of its being destroyed by ice, the result of which, considering the mill and sandy nature of the canal bank back of it, would have been very disastrous. Work on the new abutment began in October, 1891, and, with the exception of a little coping, was completed in February, 1892. The coping has since been laid and the abutment is complete.

It was found that a part of the dam was in bad shape and had to be rebuilt; 110 feet of dam was repaired and the remainder made secure. The intention is to complete the repairs during the present season.

Shipyard at McConnelsville.—The water-power planing mill did excellent service during the year. The timbers for the upper and lower gates at No. 2, upper and lower gates at No. 5, upper gates at Nos. 6 and 7, lower gates at No. 7, and lower gates for new lock No. 9 were framed.

Lock and Dam No. 8, Eagleport.—At the close of last year the repairs on this lock had been completed, but the cofferdams had not yet been removed. These were not entirely torn out until the work on the dam was completed, and the lock was not open to navigation until November. A dry masonry wall was built connecting the lower end of the land wall with the high ground, and new gate-operating machines were placed in position on the lock walls.

Work on the new dam was pushed as rapidly as the materials could be delivered. It was entirely rebuilt, with the exception of a short piece put in last season. The crest of the new dam was raised 4 feet higher than that of the old dam, in order to produce the normal conditions for which new Locks Nos. 8 and 9 were designed. The long slope of this dam is expected to cause a deposit at the foot of the dam, and by filling the deep hole immediately below the dam add to its stability.

A masonry abutment was built at the right end of the dam, and the embankment connecting it with the high ground, was raised to the height of the new abutment and the downstream slope paved.

Lock and Dam No. 9, Taylorsville.—As the new lock at Taylorsville can not be made available until a draw is placed in the county bridge just below it, all navigation at this point has been through the old lateral canal and lock. In anticipation of the opening of the new lock nothing was done to the canal, and the time required for the passage of boats at this place has not been shortened.

The dam at this place must be raised 2 feet to produce the normal conditions for which new Lock No. 9 was designed. If this were done it would be of immediate benefit to steamboats running through the canal and would avoid the necessity of dredging it this season. The old dam was extensively repaired and is in good condition.

Lock and Dam No. 10, Zanesville.—Minor repairs were made to the dam.

The lock has been in operation throughout the year. Considerable trouble and expense was incurred by the large amount of mud which accumulates in the chamber and around the gates, rendering them difficult of operation. The middle and upper gates are in very poor condition. They should be rebuilt at an early day.

BOATS.

The dredge *Malta* was in commission seven months. She did good service in removing cofferdams at Locks Nos. 2, 5, 6, 7, and 8, in digging out the canal at McConnelsville after the completion of Lock No. 7, and in dredging channel and removing snags and wrecks at various points between Marietta and Eagleport.

Drawings for new dump scows have been prepared and the timbers for building the scows bought and stored at McConnelsville.

The Government steamer *Vega* was engaged in general towing between Locks Nos. 2 and 6.

The towing for the dredge was done by the hired steamboat *Lissie Cassel.*

BRIDGES.

Railroad bridge of the Baltimore and Ohio Southwestern Railroad Company, at Marietta, Ohio.—This bridge crosses the Muskingum River just below Lock No. 1 (the Ice Harbor Lock), and practically prevents the use of this lock by all the larger class of steamboats that usually navigate the Ohio and Muskingum rivers. Nothing has yet been done towards altering this bridge, as required by the order of the Secretary of War.

The Taylorsville and Duncan Falls Bridge.—This bridge crosses the Muskingum River at Taylorsville, just below Lock No. 9, and will pre-

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vent the use of this lock unless altered. By authority granted by sections 4 and 5, river and harbor act approved September 19, 1890, the Secretary of War ordered the owners of this bridge to make the necessary alterations. This they failed to do, and the matter was placed in the hands of the Department of Justice and the parties were brought to trial. Upon the trial a *pro forma* verdict of guilty was taken by consent, with the understanding that the questions of law involved should be presented and considered on motion for new trial. The following is the opinion of the court in the case, delivered by Judge Sage, which is copied from the records of the United States clerk's office through the courtesy of Gen. B. R. Cowan, clerk of the district court.

United States District Court, Southern District of Ohio, Eastern Division.

THE UNITED STATES *vs.* FRANK M. RIDER, JOHN F. BURGESS, SAMUEL M. RUTLEDGE, COUNTY COMMISSIONERS OF MUSKINGUM COUNTY, IN THE STATE OF OHIO.

This case is before the court on motion for new trial. The defendants are prosecuted under an information founded upon the fourth and fifth sections of the river and harbor act, approved September 19, 1890. The charges are, in short, that on the 15th of October, 1891, the defendants were the county commissioners of Muskingum County, Ohio, and as such empowered by the law of Ohio to construct, alter, and keep in repair all necessary bridges over streams and public canals on all State and county roads, and then and there had control of the bridge across the Muskingum River, between Taylorsville and Duncans Falls; and the Secretary of War of the United States, having good reason to believe that said bridge was an unreasonable obstruction to the navigation of said river, a navigable stream over which the United States has jurisdiction, on the 19th of December, 1890, gave written notice to the defendants that said bridge was considered an obstruction to navigation by reason of the fact that it had no draw for the passage of boats by way of the new lock just above the south end of the new bridge at Taylorsville, Ohio, and, in order to afford defendants a reasonable opportunity to be heard and give evidence in regard to said complaint, the 6th of January, 1891, was named and a place fixed for that purpose; in that the time was extended to the 3d of February, 1891, and on the 25th of February, 1891, the Secretary gave written notice to the defendants that said bridge was an unreasonable obstruction to the free navigation of said river, for the reason above stated, and required the construction of a draw span therein in accordance with plans shown in a map attached to said notice and served upon the defendants, said notice prescribed that said draw span should be made and completed within a reasonable time, to wit, on or before the 30th of September, 1891; that personal service of said notice was made on the 3d of March, 1891; that afterwards the defendants on, to wit, the 15th day of October, 1891, after receiving said notice, did unlawfully fail and refuse to comply with the order of the Secretary and to make the alterations aforesaid, contrary to the form of sections 4 and 5 of the act above referred to. These sections are as follows:

SEC. 4. That section 9 of the river and harbor act of August 11, 1888, be amended and reënacted so as to read as follows:

That whenever the Secretary of War shall have good reason to believe that any railroad or other bridge now constructed, or which may hereafter be constructed, over any of the navigable waterways of the United States is an unreasonable obstruction to the free navigation of such waters on account of insufficient height, width of span, or otherwise, or where there is difficulty in passing the draw opening or the draw span of such bridge by rafts, steamboats, or other water craft, it shall be the duty of the said Secretary, first giving the parties reasonable opportunity to be heard, to give notice to the persons or corporations owning or controlling such bridge so to alter the same as to render navigation through or under it reasonably free, easy, and unobstructed; and in giving such notice he shall specify the changes required to be made, and shall prescribe in each case a reasonable time in which to make them. If at the end of such time the alteration has not been made, the Secretary of War shall forthwith notify the United States district attorney for the district in which such bridge is situated, to the end that the criminal proceedings mentioned in the succeeding section may be taken.

SEC. 5. That section 10 of the river and harbor act of August 11, 1888, be amended and reënacted so as to read as follows:

That if the persons, corporations, or associations owning or controlling any railroad or other bridge shall, after receiving notice to that effect, as hereinbefore required from the Secretary of War, and within the time prescribed by him, willfully fail

or refuse to remove the same, or to comply with the lawful order of the Secretary of War in the premises, such persons, corporation, or association shall be deemed guilty of a misdemeanor, and, on conviction thereof, shall be punished by a fine not exceeding $5,000; and every month such persons, corporation, or association shall remain in default in respect to the removal or alteration of such bridge shall be deemed a new offense and subject the persons, corporation, or association so offending to the penalties above prescribed.

Upon the trial, the evidence being in, a *pro forma* verdict of guilty was taken by consent, with the understanding that the questions of law involved should be presented and considered on motion for new trial. There are two questions, as follows:

(1) Was the notice to the defendants reasonable? The charges of the information in regard to the notice were established by the evidence, and are not disputed. It has been held that where the facts are clear, what is reasonable notice or reasonable time is always a question exclusively for the court. Toland *v.* Sprague, 12 Peters, 336; Wiggins *v.* Burkham, 10 Wallace, 132. It appears from the evidence that at the time of the service of said notice the defendants had no funds with which to make the required change, and that under the statutes of Ohio, they, as commissioners, could only make levies for bridge purposes at their March or June sessions in each year, one-half of which would be collectible not before the 20th of December of the year following. It also appears from the evidence that the defendants applied for legislation authorizing them to raise the funds with which to make the change required, and that their application failed, and the defendants introduced evidence tending to prove that the cost of the required change will exceed the sum of $10,000, which, however, is denied by witnesses for the Government. The defendants, under the statutes of Ohio, can not expend in constructing, altering, or repairing any bridge a sum in excess of $10,000 without special authority from the legislature, or without submitting the same to a vote of the people of the county at some general election, and there was no general election after the service of notice, excepting the spring election on the first Monday of April and the State election on the first Tuesday after the first Monday of November. The first of these dates was too early after the notice and the last was after the limit prescribed by the notice. The defendants had no authority in the matter excepting as county commissioners. They had no bridge fund to draw upon and no authority of law to incur any obligation excepting upon their individual responsibility. It would be manifestly unreasonable to expect them to proceed without the authority of local law and without money, upon their own responsibility, to incur the expenses involved in making the required changes, whether the cost would have been less or more than $10,000. The notice was not reasonable, and, therefore, if upon no other ground, the verdict must be set aside.

(2) The main question, and that which goes to the root of the matter, is whether Congress has the power to confer upon the Secretary of War the authority attempted to be conferred by the act. In accordance with its terms, whenever he has good reason to believe that a bridge is an unreasonable obstruction to navigation he is to give notice to the parties owning or controlling the same, after first giving them reasonable opportunity to be heard, to make such alterations as he may specify, and upon their failure or refusal to make the same within a reasonable time they are to be deemed guilty of a misdemeanor, and the Secretary may direct the institution of criminal proceedings. The power of the Secretary depends upon his having adjudged that the bridge is an obstruction and his adjudication is made final and conclusive. This is a judicial power. The question is one of fact, or a mixed question of law and fact, and it can not be determined by a court without a jury unless the defendant consents. It was held in Grant *vs.* Raymond, 6 Peters, 242, Chief-Justice Marshall announcing the decision, that the Secretary of State of the United States is not an officer in whom, under the Constitution, judicial power can be vested. In that case the Secretary had gone through with the form of reissuing a patent for an invention. It is true that there was not then any statute authorizing a reissue. The original patent had been granted by the President, signed by him, and countersigned by the Secretary. It was returned to the Patent Office and canceled, owing to the defective specification on which it was issued, and another patent issued with a corrected specification. The argument in favor of the reissue was that the Department of State had clearly the right to correct an inadvertent or innocent mistake. But the court said that the question of inadvertence or mistake was a judicial question, which could not be decided by the Secretary of State. It is also true that within a few months after the decision of that case Congress enacted a statute making it lawful for the Secretary of State, upon the surrender of a patent invalid or inoperative by reason of inadvertence, accident, or mistake, as specified in the act, to cause a new patent for the same invention and for the residue of the term of the original patent to be issued, the reissued patent to be liable to the same defenses as the original; and that subsequently the authority was vested in the Commissioner of Patents, with whom it remains to this day. But there is this radical difference between the case of a reissued patent and the case now before the court: The pat-

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ent, original or reissued, is only *prima facie* evidence of an exclusive right in the patentee, and it is open to all defenses, including, in the case of a reissued patent, those involving an investigation into the question whether there was in fact any such inadvertence, accident, or mistake as was requisite to authorize the reissue; while here the Secretary of War finds and decides conclusively and finally whether the bridge is an obstruction, what changes shall be made, and within what time; and the only questions left open to be tried in the criminal prosecution for misdemeanor, which he is authorized to set on foot, are whether he has made the findings and decisions, ordered the changes, given the proper notices, and whether the defendants have complied with his orders.

In this case the bridge was built about 1874 by the board of commissioners of Muskingum County, by virtue of a grant from the State of Ohio under the act of the legislature of March 25, 1870. The Muskingum River is entirely within the State of Ohio. Since 1838 and until the date hereinafter mentioned, it has been under the control of the State through its board of public works, which maintained a system of slack-water navigation until the cession of the river and its improvements by the State of Ohio to the Federal Government March 21, 1887. Since that time the General Government has caused to be constructed in a dam at the head of the rapids above said bridge, on its west side and under the bridge, an artificial channel. It has also raised the locks and dam on the river below, thus raising the level of the water above, some 4 feet. These improvements and changes furnished the occasion alleged for requiring the proposed changes in the bridge. The right of the State of Ohio to erect or authorize bridges over the river which should not interfere with its navigation is conceded, and that such bridges were lawful structures. But it is urged for the Government that they were built subject to the power of Congress at any time to act upon the subject of the navigation of the river, and to define what structures should be regarded as interfering with that navigation, citing Gilman *v.* Philadelphia, 3 Wal., 731. There is a long series of cases decided by the Supreme Court and cited in *United States* v. *Keokuk and H. Bridge* (45 Fed. Rep. at page 180), sustaining the general proposition as above stated. But the question to be here decided is whether Congress could delegate as it has undertaken to do, its authority in the premises to the Secretary of War. My conclusion is that it could not. The reasons for this conclusion are so well and so fully set forth by Judge Shiras in *United States* v. *Keokuk and H. Bridge,* cited above, that it is sufficient to refer to that case, and to express as I do my concurrence in the reasoning and conclusions of the opinion therein.

The verdict against the defendants will be set aside, and the judgment of the court will be that sections 4 and 5 of the river and harbor act of September 19, 1890, upon which the information is based, are unconstitutional, and that the defendants go hence without day.

GEO. R. SAGE,
U. S. District Judge.

MAY 14, 1892.

Muskingum River leases for year ending April 30, 1892.

Location.	Lessee.	Dated.	Expires.
Dam 1, Marietta	Phœnix Mill Company	May 1, 1878	May 1, 1903
Dam 2, Devol	Gates & Payne	May 1, 1889	May 1, 1909
Dam 3, Lowell	Milton King	Nov. 1, 1889	Nov. 1, 1909
Do	F. Wilking & Co	May 1, 1890	May 1, 1910
Do	Rechsteiner Brothers	May 1, 1890	May 1, 1910
Do	E. W. Sprague	Dec. 2, 1879	Dec. 15, 1909
Do	George Rice	Sept. 1, 1889	Sept. 1, 1909
Dam 4, Beverly	Robbins Brothers	May 1, 1889	May 1, 1909
Do	Stull & Jumper	May 3, 1889	May 3, 1909
Do	George S. Worstell	May 1, 1890	May 1, 1910
Do	Mary L. Baldwin	May 1, 1890	May 1, 1910
Do	D. T. Brown	May 1, 1890	May 1, 1910
Do	Isaac D. Spooner	May 1, 1890	May 1, 1910
Dam 6, Stockport	Joseph Newberry	May 1, 1889	May 1, 1909
Dam 7, McConnelsville	E. M. Stanberry	Sept. 1839	
Dam 8, Duncans Falls	John Miller	Dec. 31, 1836	
Dam 9, Taylorsville	Frazier & Son	Dec. 31, 1836	
Dam 10, Zanesville	John T. Drone	May 1, 1890	May 1, 1910
Do	Edward Johnson	May 1, 1890	May 1, 1910
Do	do	May 1, 1889	May 1, 1909
Do	Joseph Shaw	May 1, 1890	May 1, 1910
Do	Muskingum Coffin Company	May 1, 1890	May 1, 1910
Do	Gary & McLaughlin	May 1, 1890	May 1, 1910
Symmes Creek	Beaumont & Blankenbuhler	July 1, 1889	July 1, 1909
	Sarah V. Plummer	Apr. 2, 1889	Apr. 2, 1894

Muskingum River leases for year ending April 30, 1892—Continued.

Lessee.	Subject.	Cubic feet of water per minute.	Annual rental.	Rebate allowed.	Rents collected.
Phœnix Mill Company	Water power	3,000	$350.00	$257.73	$92.27
Gates & Payne	do	9,000	108.00	32.73	75.27
Milton King*	do	2,600	100.00		
F. Wilking & Co	do	7,280	174.72		174.72
Rechsteiner Brothers	do	4,446	106.70		106.70
E. W. Sprague	Land		5.00		5.00
George Rice	do		6.00		6.00
Robbins Brothers	Water power	1,904	100.00	4.85	95.15
Stull & Jumper	do	5,293	127.03	6.16	120.88
George S. Worstell	do	5,600	114.24	5.54	108.70
Mary L. Baldwin	do	5,000	100.00	4.85	95.15
D. T. Brown	do	6,500	118.30	5.74	112.56
Isaac D. Spooner	do	4,000	100.00	4.85	95.15
Joseph Newberry	do	6,390	230.04	28.58	201.46
E. M. Stanberry†	do	(‡)			
John Miller†	do	(§)			
Frazier & Son†	do	(§)			
John T. Drone	do	7,560	453.60		453.60
Edward Johnson	do	6,029	361.74		361.74
Do	do	7,399	443.82		443.82
Joseph Shaw‖	do				
Muskingum Coffin Company	do	4,619	207.85		207.86
Gary & McLaughlin	do	4,794	186.97		186.96
Beaumont & Blankenbuhler	do	7,741	278.68		278.68
Sarah V. Plummer¶	Land				
Total					3,221.67

* Lessee insolvent. Water shut off.
† Perpetual free lease of water power.
‡ Enough to propel 10 run of 4′ 5″ millstones.
§ Enough to propel 15 run of 4½′ millstones.
‖ Lease transferred to Muskingum Coffin Company, November 24, 1891.
¶ Terms five years in advance.

Estimate for fiscal year ending June 30, 1893.

Lock and Dam No. 1	$1,100
Lock and Dam No. 2	2,270
Lock and Dam No. 3	450
Lock and Dam No. 4	2,145
Lock and Dam No. 5	2,470
Lock and Dam No. 6	1,340
Lock and Dam No. 7	1,615
Lock and Dam No. 8	1,845
Lock and Dam No. 9	7,000
Lock and Dam No. 10	1,000
Rent, fuel, gas, and water	300
Repairs to steamer *Vega*	500
Repairs to quarter boat	500
Operating steamer *Vega* eight months	3,000
Building two new dump scows	3,000
Dredging	9,600
Salaries and wages	12,288
Contingencies	5,000
Total	55,423

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Detailed statement of expenses incurred on Muskingum River under the appropriation for operating and care of canals and other works of navigation, for the fiscal year ending June 30, 1892.

GENERAL ADMINISTRATION.

Month.	Salaries.		Plant.	
	Office force.	Lock-keepers, bridge-tender and watchman.	First cost.	Repairs.
July	$530.00	$504.00	$517.16	$149.44
August	530.00	449.00	332.79	126.72
September	530.00	449.00	1,412.31	135.13
October	530.00	414.17	148.45	128.51
November	.....	504.00	307.97	10.86
December	.....	406.50	.95	.....
January	150.00	534.00	2.80	.....
February	410.00	579.00	107.28	.....
March	380.00	579.00	.50	2.20
April	.....	524.00	2.10	.50
May	.....	524.00	.....	.....
June	380.60	449.00	.....	.....
Total	3,440.00	5,915.67	2,802.31	553.36

Month.	Buildings.	Supplies.	Transportation.	Miscellaneous.	Total.
July	$74.08	$152.85	$127.01	$302.57	$2,357.11
August	.....	30.73	11.25	72.53	1,553.02
September	.....	42.34	10.25	127.71	2,706.74
October	.....	49.40	10.80	128.66	1,379.99
November	.....	5.54	13.15	109.18	950.70
December	.....	8.58	.60	105.41	522.04
January	.....	7.99	.50	41.28	736.57
February	.....	.....	14.60	110.68	1,221.56
March	.....	34.18	.25	72.15	1,068.28
April	.....	20.95	.25	50.51	598.31
May	.....	1.00	.....	33.18	558.18
June	.....	1.20	.....	.....	830.20
Total	74.08	354.76	188.66	1,153.86	14,482.70

UNITED STATES DREDGE MALTA.

Month.	Salaries.	Equipment.	Supplies.	Repairs.	Towboat.	Total.
July	$532.10	$126.74	$185.51	$125.96	$1,220.00	$2,190.31
August	535.45	34.10	64.80	8.96	620.00	1,263.31
September	599.45	6.30	47.90	.....	600.00	1,253.65
October	604.75	.....	9.45	80.21	620.00	1,314.41
November	550.25	.....	38.36	57.90	600.00	1,246.51
April	481.77	.....	84.00	.....	460.00	1,025.77
May	239.47	.....	25.00	.....	240.00	504.47
June	112.00	.....	2.50	.....	.....	114.50
Total	3,655.24	167.14	457.52	273.03	4,360.00	8,912.93

UNITED STATES STEAMER VEGA.

Month.	Salaries.	Equipment.	Supplies.	Repairs.	Total.
July	$354.55	.....	$52.44	$19.05	$426.04
August	355.00	$0.50	30.75	21.60	407.85
September	352.50	8.30	3.90	.....	364.70
October	355.50	.....	.54	.....	356.04
November	352.50	.....	68.45	2.73	423.68
December	.....	.....	1.50	2.00	3.50
January	.....	.....	1.10	.....	1.10
Total	1,770.05	8.80	158.68	45.38	1,982.91

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Detailed statement of expenses incurred on Muskingum River, etc.—Continued.

LOCK AND DAM No. 1.

Month.	Labor.	Material.	Supplies.	Boat and engine hire.	Total.
July	$468.34	$2,248.91	$17.35	$265.56	$3,000.16
August	2,452.02	1,814.12	96.42	104.76	4,467.32
September	4,192.14	2,213.86	112.08	149.87	6,667.95
October	6,480.43	3,179.77	475.45	165.49	10,301.14
November	869.99	1,264.08	109.52	90.76	2,334.35
December		.46			.46
March		13.55			13.55
Total	14,462.92	10,734.75	810.82	776.44	26,784.93

LOCK AND DAM No. 2.

July	$699.74	$970.69	$6.38	$3.00	$1,679.81
August	3,090.01	619.31	42.61	45.00	3,796.93
September	3,047.57	1,473.69	143.83	41.50	4,706.59
October	2,969.24	1,974.32	42.90	92.83	5,079.29
November	1,988.82	1,764.63	45.19	11.50	3,810.14
December	1,018.33	480.82	18.40	10.98	1,528.53
January	569.95	456.00			1,025.95
February	44.30				44.30
March	4.80			2.00	6.80
April	3.90				3.90
May	2.40				2.40
Total	13,439.06	7,739.46	299.31	206.81	21,684.64

LOCK AND DAM No. 3.

July	$269.70	$657.17	$22.83	$57.00	$1,006.70
August	1,305.00	360.26	1.00	38.00	1,704.26
September	2,357.46	1,740.82	7.60	50.00	4,155.88
October	2,368.14	1,130.08	13.01	47.16	3,558.39
November	555.10	344.36		37.00	936.46
December		30.00		16.67	46.67
April	3.60		.60		4.20
June	3.15				3.15
Total	6,862.15	4,262.69	45.04	245.83	11,415.71

LOCK AND DAM No. 4.

July	$2,550.08	$1,334.64	$15.65	$174.16	$4,074.53
August	2,390.11	26.45	1.85	30.00	2,448.41
September	1,655.92	128.64	.50	20.00	1,805.06
October	479.57	19.70	.12	13.33	512.72
November		.35	4.50		4.85
December	56.30				56.30
January	20.25				20.25
Total	7,152.23	1,509.78	22.62	237.49	8,922.12

LOCK AND DAM No. 5.

July		$44.50			$44.50
August	$1,030.75	101.56	$3.76		1,136.07
September	3,566.28	771.06	22.77	$85.00	4,445.11
October	3,570.36	1,911.77	6.54	117.00	5,605.67
November	4,182.65	1,019.21	217.36	85.00	5,504.22
December	1,672.11	1,104.40	33.20	5.00	2,814.71
January	886.83	56.09			942.92
March	628.05	269.75	13.70		911.50
April	1,029.21	384.68	21.39	8.00	1,443.28
May	237.00			6.00	243.00
Total	16,803.24	5,663.02	318.72	306.00	23,090.98

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Detailed statement of expenses incurred on Muskingum River, etc.—Continued.

LOCK AND DAM No. 6.

Month.	Labor.	Material.	Supplies.	Boat and engine hire.	Total.
July	$4,568.55	$3,405.89	$130.38	$244.00	$8,348.82
August	4,339.92	3,164.15	5.81	72.50	7,582.38
September	2,372.62	1,783.86	7.44	55.00	4,218.92
October	2,329.20	953.55	28.20	.....	3,310.95
November	2,347.40	370.71	28.70	30.00	2,776.81
December	27.75	32.00	.....	.....	59.75
January	14.70	348.26	.....	.....	362.96
February	5.40	.....	.....	.....	5.40
March	4.95	.....	.....	.....	4.95
April	436.50	222.50	.....	.....	659.00
May	18.70	.....	.....	.....	18.70
Total	16,465.69	10,280.92	200.53	401.50	27,348.64

LOCK AND DAM No. 7.

July	$2,626.83	$3,492.54	$97.76	$69.25	$6,286.38
August	2,540.77	2,125.67	44.44	82.50	4,793.38
September	3,967.27	2,200.60	.....	45.00	6,212.87
October	6,117.47	2,588.95	87.54	15.00	8,808.96
November	3,031.80	931.71	.67	17.00	3,981.18
December	939.95	665.95	.....	20.00	1,625.90
January	149.94	347.76	.....	.....	497.70
February	169.00	.....	.....	.....	169.00
March	102.50	.....	.....	.....	102.50
April	84.60	222.75	.....	.....	307.35
May	49.05	8.36	.....	.....	57.41
June	8.40	.....	.....	.....	8.40
Total	19,787.58	12,584.29	230.41	248.75	32,851.03

LOCK AND DAM No. 8.

July	$3,410.45	$3,209.29	$39.33	$201.67	$6,860.74
August	3,469.30	3,177.85	54.13	87.25	6,788.53
September	4,040.93	3,454.80	.....	367.50	7,863.23
October	3,749.10	2,278.10	.....	498.05	6,525.25
November	2,547.33	600.12	.....	266.50	3,413.95
December	318.52	220.75	.....	31.00	570.27
January	24.00	235.52	.....	.....	259.52
February	32.57	.....	.....	.....	32.57
March	5.10	49.57	.....	.....	54.67
June	2.55	1.55	.....	.....	4.10
Total	17,599.85	13,227.55	93.46	1,451.97	32,372.83

LOCK AND DAM No. 9.

July	.....	$2.00	.....	.....	$2.00
August	.....	13.32	.....	.....	13.32
September	$440.55	532.37	.....	.....	972.92
October	914.77	433.16	$1.35	.....	1,349.28
November	40.50	2.20	.....	.....	42.70
May	.....	212.73	.....	.....	212.73
Total	1,395.82	1,195.78	1.35	.....	2,592.95

LOCK AND DAM No. 10.

July	$50.92	$3.00	$1.75	$147.00	$202.67
August	401.02	13.46	.....	.....	414.48
September	496.90	630.33	.....	.....	1,127.23
October	159.15	221.33	.....	.....	380.48
November	50.25	1.89	2.20	.....	54.34
December	1.40	10.72	.....	.....	12.12
February	15.90	.....	.....	.....	15.90
March	22.95	1.00	.....	.....	23.95
April	4.80	.....	.....	.....	4.80
June	28.95	.....	.....	.....	28.95
Total	1,232.24	881.73	3.95	147.00	2,264.92

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SUMMARY.

General administration	$14,482.70	Lock and Dam No. 6	$27,348.64
United States dredge Malta	8,912.93	Lock and Dam No. 7	32,851.03
United States steamer Vega	1,982.91	Lock and Dam No. 8	32,372.83
Lock and Dam No. 1	26,784.93	Lock and Dam No. 9	2,592.95
Lock and Dam No. 2	21,684.64	Lock and Dam No. 10	2,264.92
Lock and Dam No. 3	11,415.71		
Lock and Dam No. 4	8,922.12	Total	214,707.29
Lock and Dam No. 5	23,090.98		

Detailed statement and cost of dredging on the Muskingum River under the appropriation for operating and care of canals and other works of navigation, for the fiscal year ending June 30, 1892, to wit:

UNITED STATES DREDGE MALTA.

Date.	Locality.	Materials excavated.	Total cost.
July	Bear Creek	Gravel, sand, and mud, 6,702 cubic yards, at 15 cents	$1,005.30
	Luke Chute	Gravel, sand, and mud, 7,900 cubic yards, at 15 cents	1,185.00
August	Stones Ripple	Gravel, sand, and mud, 351½ cubic yards, at 18 cents	63.32
	Baldwins Ripple	Gravel, sand, and mud, 8,000 cubic yards, at 15 cents	1,200.00
September	Silver Heels	Gravel, sand, and mud, 5,621½ cubic yards, at 17 cents	955.65
	....do	Stone, 114 cubic yards, at $2	228.00
	....do	Snags, 7, at $10	70.00
October	Stockport	Gravel, sand, and mud, 7,349½ cubic yards, at 17 cents	1,249.41
	....do	Stone, 15 cubic yards, at $2	30.00
	....do	Snags, 3 at $5	15.00
	....do	Piling, 2 at $10	20.00
November	....do	Cofferdam, 50 linear feet, at $2	100.00
	McConnelsville	Stone, 10 cubic yards, at $2	20.00
	....do	Gravel, sand, and mud, 3,313½ cubic yards, at 24 cents	1,126.51
April	Eagleport	Piling, 7 at $5	35.00
	McConnelsville	Piling, 2 at $5	10.00
	....do	Gravel, sand, and mud, 10,008½ cubic yards, at 9 cents	900.77
	....do	Cofferdam, 40 linear feet, at $2	80.00
May	Stockport	Cofferdam, 40 linear feet, at $1	40.00
	Luke Chute	Cofferdam, 80 linear feet, at $1	80.00
	....do	Gravel, sand, and mud, 480 cubic yards, at 15 cents	72.00
	....do	Wrecked barge, 1, at $20	20.00
	Devol	Gravel, sand, and mud, 1,600 cubic yards, at 11¾ cents	190.00
	....do	Cofferdam, 40 linear feet, at $1	40.00
	Marietta	Gravel, sand, and mud, 316½ cubic yards, at 15 cents	47.47
	....do	Piling, 3 at $5	15.00
June			114.50
		Total	8,912.93

Commerce of Muskingum River during the fiscal year ending June 30, 1892.

LOCK NO. 1.

Month.	Steamboats.	Barges.	Miscellaneous.	Total.	Number of lockages.
December	2	2	6	10	10
February	1	11	13	25	25
March	5	8	7	20	20
April	58	17	66	141	141
May	54	10	31	95	95
June	81	13	41	135	115
Total	201	61	164	426	406

LOCK NO. 2.

July	8	12	4	24	24
February	37	11	4	52	48
March	54	8	6	68	66
April	54	9	2	65	64
May	69	17	5	91	91
June	82	23	7	112	112
Total	304	80	28	412	405

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Commerce of Muskingum River during the fiscal year ending June 30, 1892—Continued.

LOCK NO. 3.

Month.	Steamboats.	Barges.	Miscellaneous.	Total.	Number of lockages.
July	28	24	5	57	48
August	32	30	5	67	54
September	22	17	1	40	29
October	11	7	2	20	12
November	15	8	.....	23	15
December	.....	.....	2	2	2
February	36	5	3	44	43
March	54	9	.....	63	63
April	54	7	1	62	62
May	65	13	1	79	75
June	85	16	2	103	92
Total	402	136	22	560	495

LOCK NO. 4.

July	46	44	4	94	46
August	28	20	4	52	28
September	13	26	.....	39	33
October	14	29	.....	43	28
November	20	18	1	39	24
December	.....	3	.....	3	3
February	12	4	1	17	17
March	14	10	4	28	26
April	20	9	2	31	31
May	31	11	2	44	40
June	41	14	3	58	58
Total	239	188	21	448	334

LOCK No. 5.

July	18	10	.....	28	22
August	19	8	3	30	22
May	31	6	3	40	35
June	42	8	4	54	46
Total	110	32	10	152	125

LOCK No. 6.

October	10	10	.....	20	18
November	.....	1	.....	1	1
December	8	8	.....	16	14
April	9	2	3	14	14
May	32	3	5	40	40
June	43	4	6	53	49
Total	102	28	14	144	136

LOCK No. 7.

December	20	12	3	35	25
January	5	2	3	10	6
February	4	1	.....	5	5
March	31	1	.....	32	32
April	30	12	3	45	40
May	32	5	4	41	40
June	43	8	6	57	53
Total	165	41	19	225	201

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Commerce of Muskingum River during the fiscal year ending June 30, 1892—Continued.

LOCK No. 8.

Month.	Steamboats.	Barges.	Miscellaneous.	Total.	Number of lockages.
October	60	.....	2	62	62
November	26	.....	1	27	27
December	62	4	.....	66	64
January	11	.....	.....	11	11
February	30	.....	.....	30	30
March	85	6	4	95	90
April	85	7	1	93	93
May	77	1	4	82	82
June	98	2	6	106	106
Total	534	20	18	572	565

LOCK No. 9.

July	.....	1	7	8	7
August	1	.....	6	7	7
September	1	7	2	10	10
October	50	14	2	66	66
November	52	1	3	56	56
December	62	5	4	71	68
January	13	.....	.....	13	13
February	30	.....	.....	30	30
March	86	2	2	90	88
April	81	9	5	95	92
May	78	11	.....	89	85
June	108	14	7	129	122
Total	562	64	38	664	644

LOCK No. 10.

July	54	.....	.....	54	54
August	54	.....	.....	54	54
September	54	5	.....	59	54
October	54	3	1	58	56
November	48	4	2	54	49
December	64	3	.....	67	64
January	12	.....	.....	12	12
February	48	.....	.....	48	48
March	80	1	.....	81	81
April	76	.....	.....	76	76
May	76	2	.....	78	78
June	101	3	.....	104	104
Total	721	21	3	745	730

SUMMARY.

	Steamboats.	Barges.	Miscellaneous.	Total.	Number of lockages.
Lock No.—					
1	201	61	164	426	406
2	304	80	28	412	405
3	402	136	22	560	495
4	239	188	21	448	334
5	110	32	10	152	125
6	102	28	14	144	136
7	165	41	19	225	201
8	534	20	18	572	565
9	562	64	38	664	644
10	721	21	3	745	730
Total	3,340	671	337	4,348	4,041

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List showing amount of principal items of freight and the number of passengers carried on the Muskingum River between July 1, 1891, and June 30, 1892.

Articles.		Amount.	Articles.		Amount.
Passengers	number	31,368	Wool	tons	7½
General merchandise	tons	6,000	Lumber	do	7,200
Coal	do	3,345	Brick	do	105½
Live stock	do	245	Hay	do	4,862
Oil	do	7,121	Salt	do	300
Wheat	do	621½	Potatoes	do	126½
Corn	do	1,174½			

The above statement of the commerce of the Muskingum River is complete, but is only for part of the fiscal year, as the locks were shut off for repairs and there was no through navigation until May 6, 1892.

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APPENDIX E E.

IMPROVEMENT OF FALLS OF THE OHIO RIVER, OF WABASH RIVER, INDIANA AND ILLINOIS, AND OF WHITE RIVER, INDIANA; OPERATING AND CARE OF LOUISVILLE AND PORTLAND CANAL, KENTUCKY.

REPORT OF LIEUTENANT-COLONEL G. J. LYDECKER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Falls of Ohio River, at Louisville, Kentucky.
2. Indiana Chute, Falls of the Ohio.
3. Operating and care of Louisville and Portland Canal, Kentucky.
4. Wabash River, Indiana and Illinois.
5. White River, Indiana.

UNITED STATES ENGINEER OFFICE,
Louisville, Ky., July 9, 1892.

GENERAL: I have the honor to transmit herewith reports on operating and care of the Louisville and Portland Canal, and on the improvements of the Falls of the Ohio, Louisville, Ky., Indiana Chute, Falls of the Ohio, Wabash River, Indiana and Illinois, and White River, Indiana, for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

E E 1.

IMPROVEMENT OF FALLS OF THE OHIO RIVER, AT LOUISVILLE, KENTUCKY.

The improvements in progress under this appropriation are designed to give increased facilities for passing the Falls of the Ohio via the Louisville and Portland Canal. They consist in enlargements at the upper entrance to the canal and immediately above the locks at the

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lower end, in such manner as to form capacious basins, or harbors, at those points.

The project for the enlargement at the head of the canal was inaugurated in 1883, and modified in 1890, as recommended in the report of the Board of Engineers, dated January 28, 1890. The general width of the canal before enlargement was 90 feet; when the work is completed, as shown on the sketch submitted herewith, the width for a length of 2,400 feet will be from 210 to 325 feet; immediately to the eastward of this enlargement of the canal proper a basin about 800 feet wide and 2,200 feet long will be constructed, which will be closed by a bear-trap structure 800 feet long on the west and by a concrete dam 2,800 feet long on the north. The execution of this project requires, as its principal features, the excavation of about 325,670 cubic yards of solid rock and 270,000 cubic yards of earth; the construction of about 5,200 linear feet of new canal wall and masonry dams, containing in all about 26,000 cubic yards of masonry, and the removal of about 6,200 linear feet of old canal wall, dikes, and timber dams.

The work completed prior to June 30, 1891, comprised 124,027 cubic yards of rock excavation, 197,769 cubic yards earth excavation, and 10,307 cubic yards of masonry in new canal wall.

Operations for the past fiscal year were commenced July 21, 1891, when the river had fallen to a stage sufficiently low to permit the area of excavation to be cleared of water, by pumping and the erection of temporary dam, and the active work of excavation was begun July 26. It was continued until November 23, with a temporary suspension from August 28 to September 7 on account of high water. Up to August 28 the work was carried on by day only, but after resuming in September a night force was also organized, and was continued during the remainder of the working season. No masonry was laid on this portion of the work during the year, operations being limited to earth and rock excavation; but preparations for completing the new canal wall during the ensuing season were commenced June 15, 1892. The amounts excavated during the year were 15,299 cubic yards earth and 42,856 cubic yards rock, an average of 650 cubic yards daily during the working period. A considerable portion of the area remaining to be excavated has been drilled ready for blasting.

For blasting the rock in place 9,624 holes, aggregating 49,642 feet in length, and 18,362 block holes, aggregating 13,772 feet, for breaking the blasted rock, were drilled during the season; 29,567 pounds of dynamite and 875 pounds of black powder were used for blasting.

The total work done to June 30, 1892, is as follows: Earth excavation, 213,068 cubic yards; rock excavation, 166,882 cubic yards; masonry in canal wall, 10,307.5 cubic yards.

The principal items of work remaining to be done to complete the improvement is, approximately, as follows: Rock excavation, 158,787 cubic yards; earth excavation, 53,000 cubic yards; masonry, 16,000 cubic yards, and the removal of about 6,200 linear feet of old wall, dikes, and dams.

The other portion of the improvement, viz, the canal enlargement above the locks, has been carried on in accordance with the project authorized in the Annual Report of the Chief of Engineers for 1887, the purpose being to construct at that point a basin wherein boats may lie and tows may be properly formed, before or after passing the locks, without interfering with navigation through the canal. The work approximately estimated as necessary to this end was the excavation of about 124,000 cubic yards of earth, 13,000 cubic yards of rock, the con-

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struction of about 5,200 cubic yards of masonry wall, and the removal of 1,050 feet of old canal wall on the north side. The result will be a basin at the lower end of the canal 1,500 feet long, with a width varying from 210 to 250 feet.

At the close of the fiscal year ending June 30, 1891, there had been excavated 133,617 cubic yards of earth, 14,581 cubic yards of rock, and 1,908 cubic yards of masonry had been laid in the new wall.

Operations for the fiscal year just closed were commenced early in July, 1891, and carried on with but little interruption until November 20, when high water and cold weather caused a suspension for the winter; they were resumed May 14, 1892, and continued until June 7, when temporarily suspended because of lack of available funds. Progress was in the highest degree satisfactory, and for this fact great credit is due to the energy and skill of the assistant engineer, Mr. R. R. Jones, in immediate charge; for it was through his exceptional capacity that the work received the full benefit of an unusually favorable season. He is entitled to this official recognition of his valuable services.

The results accomplished during the year were 11,760 cubic yards of earth excavated, 3,364.6 cubic yards of rock excavated, and 3,704.7 cubic yards of masonry placed in new wall, besides 195 cubic yards of temporary dry stone wall laid. In addition about 1,570 cubic yards of rock were removed from the old canal wall.

But little work is required to complete this portion of the improvement, being the removal of what remains of the old canal wall, the excavation of the underlying rock, and the construction of a length of about 50 feet of the new canal wall. It is anticipated that all this will readily be accomplished during the ensuing working season.

The amount expended under appropriations for improving the Falls of the Ohio River at Louisville, Ky., to June 30, 1892, was $619,079.43, of which sum $152,225.60 was expended during the past fiscal year, including liabilities outstanding July 1, 1892. The estimated cost of completing the improvements contemplated by the present project is $610,008.89.

The following statistics of traffic and commerce indicate the extensive river tonnage directly interested in the substantial and complete improvement of the Falls of the Ohio. They show a traffic of 7,939 boats passing this point during the past fiscal year, carrying 2,172,661 tons of freight. The annual average for the past eleven years is 7,025 boats, with about 2,500,000 tons of freight. Of coal alone the amount passing the falls to points below during the past six years has averaged 1,731,308 tons annually.

Statement of vessels passing Falls of the Ohio River via Louisville and Portland Canal and Indiana Chute, June 30, 1882, to June 30, 1892.

Kinds of vessels.	1882-'92.		1892.		Total for 11 years.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Passenger boats	11,156	4,506,402	949	425,746	12,105	4,932,148
Tow boats	11,476	1,510,731	1,477	198,218	12,953	1,708,949
Government boats	1,107	76,536	143	12,522	1,250	89,058
Coal boats and barges	43,287	14,202,133	5,162	1,811,723	48,449	16,013,856
Small craft	2,251	.....	201	.....	2,452	.....
Rafts	54	.....	7	.....	61	.....
Total	69,331	20,295,802	7,939	2,448,209	77,270	22,744,011

Annual average during past 11 years: Boats, 7,025; tons, 2,067,638.

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Statement of commerce passing the Falls of the Ohio River via Louisville and Portland Canal and Indiana Chute, from June 30, 1887, to June 30, 1892.

Articles.	From 1887 to 1891.	From 1891 to 1892.	Total for six years.
	Tons.	*Tons.*	*Tons.*
Coal	8,672,543	1,715,308	10,387,851
Salt	63,091	8,532	71,623
Oil	44,823	2,839	47,662
Whisky	12,869	1,934	14,803
Tobacco	56,021	4,329	60,350
Cotton	66,193	10,068	76,261
Lumber	2,838,793	69,769	2,908,562
Corn and wheat	42,834	18,529	61,363
Iron ore	254,516	16,383	270,904
Iron	20,229	111,776	132,005
Steel rails	205,005	46,075	251,080
Produce	33,412	9,736	43,148
Hay and straw	118,457	6,375	124,832
Flour	8,639	1,013	9,652
Stock	42,347	5,890	48,237
Sugar and molasses	42,114	7,280	49,394
Staves and shingles	215,537	3,722	219,259
Peanuts	982	.....	982
Malt	695	.....	695
Cement	9,549	8,025	17,574
Miscellaneous	297,407	125,073	422,480
Total	13,046,056	2,172,661	15,218,717

Annual average during past six years, 2,536,453 tons.

Reports of R. R. Jones and G. W. Shaw, assistant engineers, containing details of operations in their respective charges, are herewith submitted.

Money statement.

July 1, 1891, balance unexpended	$193,146.17
June 30, 1892, amount expended during fiscal year	148,182.45
July 1, 1892, balance unexpended	44,963.72
July 1, 1892, outstanding liabilities	4,043.13
July 1, 1892, balance available	40,920.57
Amount appropriated by act approved July 13, 1892	60,000.00
Amount available for fiscal year ending June 30, 1893	100,920.57
Amount (estimated) required for completion of existing project	550,008.89
Amount that can be profitably expended in fiscal year ending June 30, 1894	300,000.00

Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. R. R. JONES, ASSISTANT ENGINEER.

LOUISVILLE, KY., *June 30, 1892.*

COLONEL: I have the honor to submit the following report of operations for improving Falls of Ohio River at Louisville, Ky., enlarging canal basin at head of locks, for the fiscal year ending June 30, 1892:

IMPROVING FALLS OF OHIO RIVER, ENLARGEMENT OF BASIN.

Cofferdam at dry dock, pier, etc.—A cofferdam was constructed parallel to and about 30 feet distant from the old pier, separating dry dock from canal. This dam was 16 feet high and about 400 feet in length, and behind this protection the construction of wall between dry dock and basin was carried on.

The excavation of material was carried on from the pit until November 20, the ma-

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terial being removed on cars by the hoisting engine and incline and by carts. The latter were used only toward the close of the season's work for removal of part of the outside bank, under the protection of which the work had been heretofore carried on. The pit was allowed to fill November 20, and after that the regular canal dredges were employed, whenever the stage of water permitted, in the removal of old wall and the earth backing behind same.

Excavation.—The following material has been excavated from the commencement of the work to the close of the present fiscal year: Earth, 141,593 cubic yards; rock, 17,744.6 cubic yards; total, 159,337.6 cubic yards.

Of this total of 159,337.6 cubic yards there were excavated during the fiscal year: Earth, 11,760 cubic yards; rock, 3,364.6 cubic yards; total, 15,124.6 cubic yards.

The removal of what remains of the old canal wall will be done with dredges. The rock under the wall will be blasted under water and also removed with dredges.

New canal wall.—The work of building new canal wall was carried on during the season of 1891 up to November 2, and was resumed May 14, 1892, and carried on at intervals whenever the stage of water permitted up to June 7, 1892.

During the season of 1891 the work was conducted in the pit by means of derricks and traveling crane.

In 1892 the work was done by means of a derrick boat, as the old canal wall was by that time partly removed.

The wall is now completed excepting the short curve joining the new wall to pier head of new locks. This will be done under the protection of a small cofferdam to be constructed as soon as the water falls sufficiently.

The total quantity of masonry laid from the commencement of work to the close of fiscal year was:

	Cubic yards.
Concrete foundation	169.20
Masonry	5,443.98
Dry wall	194.20
Total	5,807.38

Of the total quantity of masonry reported—viz, about 5,807.38—there was laid during the fiscal year ending June 30, 1892:

	Cubic yards.
Concrete foundation	61.00
Masonry	3,643.68
Dry wall	194.20
Total	3,898.88

The facilities for handling and laying stone, more particularly the traveler used in construction of double wall between dry dock and basin, proved admirable. The stone used in construction of this wall weighed from 8,500 to 10,000 pounds, the headers being 10 feet long, and they were handled quickly and securely.

EXCAVATION FOR NEW CANAL WALL AT HEAD OF CANAL.

Much preparatory work was done in the way of laying railroad tracks, bridging the outlet to new portion of canal, and building earth embankments to protect the excavation.

Work was commenced June 15, 1892, the water then for the first time being low enough to permit the prosecution of the work described.

The material excavated was as follows:

	Cubic yards.
Earth	1,424
Loose rock	107
Total	1,531

This work was mostly done in the neighborhood of the Fourteenth Street Railroad Bridge, and was for the purpose of connecting the end of the new canal wall as now built with the old canal wall, about 705 feet west and south of the north drawpiers of the bridge in question.

Very respectfully, your obedient servant,

R. R. JONES,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

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REPORT OF MR. G. W. SHAW, ASSISTANT ENGINEER.

LOUISVILLE, KY., *June 30, 1892.*

COLONEL: I have the honor to submit the following report of operations on improving falls of the Ohio River at Louisville, Ky., enlarging the head of the Louisville and Portland Canal for the fiscal year ending June 30, 1892.

The work of enlarging the head of the Louisville and Portland Canal was begun in 1885, and was let by contract in three sections. Section 1 was completed in November, 1886, and the contracts for sections 2 and 3 expired December 31, 1888. The work has since been carried on with hired labor, and that of last season directed mainly to finishing sections 2 and 3. Work on section 4, an additional area north of section 3, was commenced during the last season. The material removed consisted principally of solid rock, ranging from 3 to 6 feet deep, the grade being that of the canal bottom.

There was also removed a considerable quantity of earth, mud, and deposit which accumulates during high water.

The season of 1891-'92 was particularly favorable for work, excavation having been carried on for ninety days. Preparations for beginning work were completed early in July, but high water interfered with pumping until July 21. Steam drills were put in operation on the 26th and excavation commenced on the 27th of July. A rise in the river suspended general work from August 28 to September 7. Excavation was resumed on the latter date and continued until November 23 at noon, at which time the river flooded the inclosure and work was suspended for the season.

It is estimated that the following quantities were excavated and removed during the season: Earth, mud, loose rock, etc., 15,299 cubic yards; solid rock (measured in place), 42,855.49 cubic yards.

Beginning with September 14 an additional force of men was employed at night. The inclosure was illuminated with gasoline torches and the excavated material loaded into dump cars. It is estimated that the night force excavated and loaded into cars 8,448 cubic yards of solid rock, which was removed by 632 trains, carrying 11,882 cars, averaging about seven-tenths of a cubic yard per car, measured in place.

Two 12-inch centrifugal pumps were used in pumping out the excavated area, and leakage through the guiding dike and old canal wall was controlled by temporary earth dams, which carried the water around the edge of the inclosure into the river north of the improvement. The upper part of the guiding dike was repaired and paved with stone taken from the excavated material.

The following statement shows approximately the work done to June 30, 1892: Earth excavation, 213,068.06 cubic yards, of which 15,299 cubic yards were removed in the season 1891-'92; rock excavation, 166,882.40 cubic yards, of which 42,855.79 cubic yards were removed in season 1891-'92; masonry in new canal wall laid to end of fiscal year, 10,307.56 cubic yards.

There remains to be done the following: Earth excavation, 53,000 cubic yards; rock excavation, 158,787 cubic yards; masonry in canal wall, 6,013 cubic yards; removing old canal wall, 7,500 cubic yards; removing part of dam and guiding dike, 2,900 linear feet; building concrete dam, 4,822 cubic yards; building bear-trap structure, 800 linear feet; slope revetment and wall on south side of the canal below Tenth street, 2,300 cubic yards; and the construction of 4 guide piers or cribs along the north line of the improvement above Tenth street.

Herewith is submitted a sketch showing progress of work to June 30, 1892.

Very respectfully, your obedient servant,

GRANVILLE W. SHAW,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

E E 2.

IMPROVEMENT OF INDIANA CHUTE, FALLS OF THE OHIO RIVER.

The Indiana Chute is the main river channel over the Falls of the Ohio; originally very crooked, filled with dangerous rocky points projecting from the sides and bottom and with swift changing currents, it was available for navigation by skilled pilots only when the river was above a stage of about 11 feet on the gauge of the Louisville and Portland Canal. Prior to 1890 some work had been done towards its improvement by blasting out the most dangerous points whereby the

safety of navigation was increased, but the channel was not thereby made available for heavy traffic at stages of water materially lower than that stated above. On the 28th of January, 1890, a project, having for its object the radical improvement of the channel so as to make it safely navigable at all stages above 8 feet on the canal gauge, was recommended by a Board of Engineers after close study of the question, and this project was approved by the Chief of Engineers, January 31, 1890. (See Report of Chief of Engineers for 1890, pages 2217 to 2221.) It contemplates the better concentration in this channel of water passing the falls by the erection of guiding dikes and the excavation of rock within the limits of proposed channel to a designated grade; the improved channel is designed to have a least width of 400 feet, with a clear depth of not less than 8 feet at its lowest navigable stage. The principal items of work in the execution of this project are the excavation of about 60,000 cubic yards of solid rock, the construction of about 3,700 linear feet of stone dikes, and of a concrete wall 850 feet long. The project contemplates, ultimately, some modification in the present system of dams at the head of the falls when these dams are replaced by permanent structures, but the details of such modification have not yet been decided.

Operations during the past year were limited to raising the old guiding dike—575 feet long on the north side of the chute at its entrance—2 feet, the first 50 feet constituting the pier head being raised 9 feet higher, or 11 feet in all; the cross dam, connecting this dike with the Indiana shore, was rebuilt above the water line, and some minor repairs were made to the balance of the cross dam. About 72,900 feet B. M. of oak timber and 344 cubic yards stone filling were applied to these repairs. The stage of water did not permit any rock excavation, with the appliances available, until October 5, when the work was commenced by hand-drilling; on the 9th the steam-drilling scow belonging to the Louisville and Portland Canal was put on the work, and operations were continued until November 17, when a rise in the river compelled a suspension for the season. The results accomplished during this short period were 3,163 holes, aggregating 6,474 linear feet, drilled by hand; 673 holes, aggregating 2,592 linear feet drilled by steam drills; blasting out in all about 1,474 cubic yards of rock, using for this purpose 4,825 pounds dynamite. This is the only work so far done in carrying out the present project, no suitable plant for the work in view having been procured, while all operations have been restricted to short periods of dead low water, and to the primitive and expensive method of hand-drilling. It is proposed to procure proper machinery for carrying on the work in the future, and make provision for operations during all ordinary low water, at least.

The relief which this improvement is designed to afford the heavy tonnage—especially of coal—passing the falls, is a matter of high importance. A coal tow in reaching this point frequently contains twelve to fifteen boats and barges carrying about 320,000 bushels (about 1,216 tons) of coal, bound for points on the Ohio and Mississippi between here and New Orleans; under existing conditions these tows, when unable to descend the Indiana Chute, must be broken on arrival at this point, passed through the Louisville and Portland Canal and locks in sections, and then again consolidated before continuing their journey to destination; all this imposes great delay and expense on this traffic, and not unfrequently it happens that, when a rise in the river has brought numerous tows down to this point, the later arrivals after finally passing the locks find the river too low to continue their journey, and are compelled to lie over indefinitely, sometimes for an entire season. An im-

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provement that promises to mitigate such a condition of affairs is of paramount importance, and, having been undertaken, it should be pushed to completion as soon as possible.

The statistics accompanying this report and the report in relation to the Louisville and Portland Canal show that during the past year 1,715,308 tons of coal passed the Falls of the Ohio, of which 1,232,998 tons were subject to the delays incident to transit through the canal. With the completion of the improvement now under consideration it is highly probable that none, or at most a very insignificant percentage, of the coal traffic would be subject to any such delay, while general traffic through the canal would be relieved from the blockade frequently established by the large coal fleets. The total traffic through the canal during the past year comprised 6,029 boats, carrying 1,620,586 tons of freight; that passing the falls via the Indiana Chute included 1,910 boats with 552,125 tons of freight; total passing by canal and river, 7,939 boats, with 2,172,661 tons of freight. The average for the past eleven years is annually 7,025 boats, with 2,067,638 tons of freight.

The estimated cost of the work proposed by the Board of Engineers was $138,610.97; the amount then available for the purpose was $23,885.20, and there was appropriated by the river and harbor acts approved September 19, 1890, the sum of $25,000, a total to June 30, 1892, of $48,885.20. The amount expended on the present project to June 30, 1892, was $137,476.24. The amount estimated below for the year ending June 30, 1894, is predicated on the idea that the river and harbor bill now pending in Congress will appropriate for the work $35,000. If it should happen that such appropriation be not made the estimate for 1894 should be correspondingly increased in order that the improvement may be completed as designed.

A statement of traffic and commerce are given below, and the report of G. W. Shaw, assistant engineer, in immediate charge of this improvement, is appended hereto.

Money statement.

July 1, 1891, balance unexpended	$48,885.20
June 30, 1892, amount expended during fiscal year	21,361.44
July 1, 1892, balance unexpended	27,523.76
July 1, 1892, outstanding liabilities	14.63
July 1, 1892, balance available	27,509.13
Amount appropriated by act approved July 13, 1892	35,000.00
Amount available for fiscal year ending June 30, 1893	62,509.13
Amount (estimated) required for completion of existing project	57,249.53
Amount that can be profitably expended in fiscal year ending June 30, 1894	60,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. G. W. SHAW, ASSISTANT ENGINEER.

LOUISVILLE, KY., *June 30, 1892.*

COLONEL: I have the honor to submit the following report of operations on improving Falls of the Ohio River—Indiana Chute—for the fiscal year ending June 30, 1892.

The work of the season of 1891 was devoted to raising the guiding dike at the upper end of the chute and to the blasting and removal of Right Hand Reef. Fifty feet of the upper end of the guiding dike was raised 11 feet to Ref. 51 to serve as a guide pier for descending navigation. The remainder of the dike, 524½ feet, was raised 2 feet to Ref. 42.

Tools and material having been brought up from the storehouse at the locks, the

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work of raising the dike began on September 21, 1891. In removing the old decking for the guide pier it was found that the timbers above low water were rotten, and new material was substituted. In the remainder of the dike the new timbers were placed on top of the old structure, care being taken to remove such as were found to be defective. Corrections in alignment were made and the new work filled with stone taken from the vicinity and from the excavation on Right Hand Reef. The upper end of the guide-pier was covered with three-eighths inch boiler iron as a protection against ice and drift. The work on the dike was completed on November 19.

Repairs to the cross dam and abutments consisted in replacing defective timbers and decking; in rebuilding the south abutment of the middle chute, and placing therein new clutches for the movable dam; in the construction of a crib abutment at the end of the dam, north of the Indiana Chute, and in rebuilding that portion of the cross dam immediately north of the Indiana Chute.

Excavation in the chute was directed to the right-hand reef and to some projections near the lower end of the guiding dike. On October 2, the river having fallen to a working stage, a breakwater was placed at the lower end of the guiding dike and hand drilling was begun on the 5th. On the 9th the drill boat belonging to the canal was placed in the chute near the lower end of the reef and the boiler utilized for drilling by steam. Steam drilling was continued until the 29th, at which time all the exposed portions of the reef had been drilled. Blasting on this part of the reef was commenced on October 11 and continued until November 17, on which date a rise in the river compelled a suspension of work for the season. Material removed from the reef was piled north of the line of improvement, and it is proposed to utilize part of it in the new wall which is to extend from the bridge eastwardly along the north line of improvement. During the season there were drilled 3,836 holes, ranging from 1 to 5 feet deep. It is estimated that 2,513 cubic yards of solid rock were blasted, of which 763 were removed. Tools and appliances were stored at the locks at the end of the season.

Very respectfully, your obedient servant,

GRANVILLE W. SHAW,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Statement of vessels passing Falls of the Ohio River, via Indiana Chute, for fiscal year ending June 30, 1892.

Kind of vessel.	No.	Tonnage.
Passenger boats	344	177,286
Towboats	469	75,574
Square barges	1,024	582,572
Model barges	73	58,400
Total	1,910	893,832

Days navigable: Ascending, 51; descending, 285.

Statement of commerce passing Falls of the Ohio River, via Indiana Chute, for fiscal year ending June 30, 1892.

Articles.	Tons.	Articles.	Tons.
Coal	482,310	Iron	7,366
Salt	1,084	Miscellaneous	25,240
Oil	750	Produce	517
Whisky	315	Flour	169
Tobacco	579	Sugar and molasses	519
Cotton	1,509	Hay and straw	710
Lumber	2,521	Live stock	648
Corn	831	Staves and shingles	3,722
Wheat	236		
Iron ore	3,517	Total	552,125
Steel rails	19,582		

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Number of passengers, 7,246.

E E 3.

OPERATING AND CARE OF LOUISVILLE AND PORTLAND CANAL, KENTUCKY.

The work of operating the canal during the past year has been carried on by a regular force, consisting of a lock manager, a deputy lock manager, a lock master, an assistant lock master, 4 engineers, 4 firemen, 4 lock hands, 1 bridge tender, 1 night watchman, and 1 laborer. The general regulation of affairs connected with the locks and of transit through the canal is controlled by the lock manager and his deputy; for the purpose of operating the locks the general force is divided into two reliefs, one in charge of the lock master, the other of the assistant lock master, and the time is so regulated as to give each relief equal periods of day and night service. The duty and responsibilities of the assistant lock master are identical with those of lock master, and it is only proper that he should have the same pay and title. It is proposed to adopt this course in future.

During the past year the locks were in operation on 342 days, and closed 23 days because of high water. The number of craft passing the locks during the year was 6,029, with a total tonnage of 1,554,377, carrying 1,620,586 tons of freight.

The care of the canal is independent of its operating force, and under the immediate supervision of an assistant engineer, who has charge of all improvements and repairs pertaining to the work. The principal operations during the year have comprised dredging, the completion of two new middle gates, trimming canal wall, ordinary repairs of dredges, boats, and buildings, and the partial reconstruction, in masonry, of the machine shop which was destroyed by fire on the evening of February 12, 1892. The following is a summary of the work done:

DREDGING.

This service is performed by 2 dredges, 4 mud scows, and a towboat, and is a constant one when the stage of water permits; it is necessary for clearing the canal and its approaches from the extensive deposits of mud and sand contributed by the river, especially after any considerable rise, when these deposits are sometimes 4 to 6 feet in depth. The total amount dredged from the canal during the past year was 86,825 cubic yards in a total working time of 276 days. In addition to this, the dredges were employed in removing stone and earth from the old canal wall, for opening up the new basin that has been constructed immediately above the locks, and in removing the cofferdam, under cover of which the basin was constructed. The amount of material handled in this work was about 10,000 cubic yards.

NEW MIDDLE GATES.

The construction of these gates, commenced during the previous fiscal year, was completed in October, 1891, from which time they remained on the ways until April, 1892, when they were successfully launched during the high water then prevailing, and are now afloat in the canal, in readiness to be put in position when the water falls to such a stage that the locks may be closed temporarily with the least interference with navigation. In the mean time the old anchors and guy rods of the suspension columns of these gates have been replaced in a most substantial manner; the old anchors extended only 7 feet into the masonry of the lock walls, and under the heavy strain brought

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on them by the large gates they had yielded to such an extent as to require the introduction of additional temporary guy rods to sustain the columns. The new anchors, 6 for each column instead of 5, as in the original system, are let into the masonry to a depth of 20 feet, and they may be counted upon with certainty to remain absolutely firm under any strain that may be brought upon them. The computed weight of the new gates is 100 tons each.

TRIMMING CANAL WALL.

This work can be done only at extremely low water, and it was carried on as usual whenever opportunity offered. Its object is to secure passing boats from damage by striking against projecting points that were originally left in the lower courses of the canal wall and on the faces of the underlying rock. This work should be continued until all such projections have been removed.

NEW MACHINE SHOP.

On the evening of February 12, 1892, the old frame building which comprised the engine and boiler house and machine shop was totally destroyed by fire, the cause of which remains a complete mystery. Its reconstruction, as a fireproof structure, was immediately undertaken, and at the close of the fiscal year had been nearly completed. The walls of the new structure are of stone masonry and the roof of corrugated iron. The destroyed building was surrounded by others of like inflammable character, viz: The blacksmith shop, carpenter shop, and two storehouses, all of which were saved only by the greatest exertion; had there been any wind they must have been completely destroyed. These buildings should be reconstructed in masonry as opportunity offers.

NEW WINDING ENGINE.

This engine was purchased and put in position in January, 1892, and properly housed in a small masonry building. It is used for handling tows in their passage through the locks, and their lockages are very greatly facilitated and expedited thereby.

GENERAL REPAIRS.

Considerable repairs were made to the towboat; they included raising the pilot house four feet; extending the cabin forward, thereby adding a much-needed room to the cabin accommodation; building a new wheel, and placing new canvas deck and roof covering. New canvas covering was placed on the roof of the old dredge, and both dredges were supplied with new spuds and dipper handles; minor general repairs were made to machinery of dredges and towboat. The old gates of dry dock were repaired and strengthened, and frequent repairs were made to the several lock gates, the principal of which were replacing nine cast-iron wickets and bearings for the same; a number of broken truss rods were replaced, and the gate maneuvering chains were repaired on several occasions. The three old bridges spanning the canal called for considerable repairs of their roadway systems. The old wooden truss bridge over the old locks is in a badly rotted and dangerous condition, and should be replaced without fail during the ensuing year. Two of the old mud scows have been partly rebuilt.

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PROPOSED WORK FOR THE YEAR ENDING JUNE 30, 1893.

In addition to the regular work required for the proper care and operation of the canal, it is proposed to build new guard gates for the old locks, to revet the earthen slope adjoining the new basin above the locks up to the ordinary high-water line, to excavate to grade the rock in the approach to the lower lock if a suitable low-water stage is reached, to replace the old dredge by a new hydraulic machine, and to replace the old unsafe bridges spanning the canal at the old and new locks. Other items of proposed work, which have been included in previous allotments, are contained in the estimate submitted below.

In relation to the necessity for the work now proposed for the first time, I would state that the slope revetment is necessary to prevent the newly-made earthen slopes from being destroyed and washed into the canal by each recurring high water.

The old dredge (No. 1) has been in use on the canal for many years, and is kept in service only with constant repairs, while her capacity for work is very small. The character of material deposited in the canal is such that it can be removed most rapidly and economically by pumping, and to that end I have included the estimate for building the hydraulic dredge to replace the old wornout dipper machine. In this connection I would recall the fact that this purpose was suggested in my letter of April 28, 1892, wherein I recommended that the new wall at the head of the canal be built without sluiceways for flushing out the canal, with a consequent saving of some $90,000 in cost, and that a suitable hydraulic dredge be built instead of such sluices.

The estimate for the past year included the reconstruction of the old highway bridge at the new locks, bids for which were received, but all of which were rejected as unsatisfactory. This year's estimate includes, in addition, an amount for rebuilding the old bridge at the old locks. This is a wooden swing-bridge, so badly rotted that it has had to be reënforced from below, in such manner that it can not be opened when it may become necessary to use the old locks, and is unsafe in every way for any but the lightest travel. It is believed that a contract for building both bridges can be made to better advantage than to make separate contracts for each at different times.

The estimates for extra labor, general repairs, miscellaneous, fuel, oil, etc., and for contingencies, have each been slightly increased to meet the requirements of completing and refitting the machine shop, and to make some extensive repairs that are badly needed to the various buildings and fences pertaining to the work.

The total estimated cost of operating and care of the canal for the year ending June 30, 1893, is as follows:

Regular force	$36,000.00
Extra labor	7,000.00
General repairs	7,000.00
Miscellaneous, fuel, oil, etc	7,000.00
New guard gates, old locks	6,000.00
New bridges at new and old locks	16,000.00
Building one hydraulic dredge	20,000.00
Completing repairs to old mud scows	2,000.00
Slope revetment above new locks	4,000.00
Rock excavation, channel below locks	15,000.00
Trimming canal walls and rock below	2,500.00
Extending city water pipes to locks	3,000.00
Contingencies	7,000.00
	132,500.00
The unexpended balance from allotment of last year, exclusive of liabilities outstanding June 30, 1892	30,324.06
The additional allotment required for the year ending June 30, 1892	102,175.94

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The usual statements of expenditures and commerce on the canal are given below, and the report of R. R. Jones, assistant engineer, charged with the care of the canal, is transmitted herewith.

Financial statement for operating and care of the Louisville and Portland Canal for the fiscal year ending June 30, 1892.

Receipts:	
Dockage	$165.42
Rent of land	285.00
Total	450.42
Expenditures:	
Office and general administration	5,976.52
Canal and locks	40,593.85
Dredging	18,499.58
Total	65,069.95
Rebuilding two mud scows	1,155.75
Trimming canal wall and rock below	1,573.76
Building new middle gates	5,153.66
New winding engine	1,026.14
Aggregate	73,979.26

Statement of expenditures for operating and care of Louisville and Portland Canal for the fiscal year ending June 30, 1892.

Office and general administration:	
Salaries	$4,910.03
Supplies	114.07
Miscellaneous	952.42
Total	5,976.52
Canal and locks:	
Labor	21,687.16
Supplies	3,400.64
Repairs and extra labor	15,506.05
Total	40,593.85
Dredging:	
Labor	10,445.67
Supplies	4,344.21
Repairs	3,709.70
Total	18,499.58
Grand total	65,069.95
Rebuilding two mud scows	1,155.75
Trimming canal wall and rock below	1,573.76
Building new middle gates	5,153.66
New winding engine	1,026.14
Aggregate	73,979.26

Abstracts of proposals for furnishing and delivering forage at the Louisville and Portland Canal received in response to the advertisement dated April 25, 1892, and opened May 26, 1892, by Lieut. Col. G. J. Lydecker, Corps of Engineers.

Articles.	Quantity (more or less).	(1) Bid of B. B. Connor.	(2) Bid of Geo. Becker & Co.*
Best timothy hay ... pounds	10,000	† $0.80	† $0.80
Best black oats ... bushels	300	.44	.40
Best ear corn ... do	100	.50	.55
Best wheat straw ... pounds	100	†.40	†.40
Best middlings bran ... do	600	†.70	†.75
Total		266.60	259.90

* Accepted. † Per hundredweight.

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Abstract of proposals for furnishing coal received in response to the advertisement dated April 25, 1892, and opened May 26, 1892, by Lieut. Col. G. J. Lydecker, Corps of Engineers.

Kind of coal.	Quantity (more or less).	(1) Bid of Austin H. Dugan.*	(2) Bid of Jos. Walton & Co.†
Best Pittsburg coal ..... bushels..	10,000	$0.11	$0.11
Second pool Pittsburg coal ..... do ...	9,000	.11	.11
Ohio River or Kanawha coal ..... do ...	53,000	.09	.....
Anthracite egg coal ..... tons..	8	7.25	7.00
Anthracite nut coal ..... do ...	8	7.25	7.00
Total	.....	6,085.00	.....

* Accepted. † No bid on principal item.

Abstract of proposals for removing old and erecting new drawbridge at the locks of the Louisville and Portland Canal, received in response to the advertisement dated April 18, 1892, and opened May 10, 1892, by Lieut. Col. G. J. Lydecker, Corps of Engineers.

No.	Name of bidder.	Price.	To be completed—
1	Toledo Bridge Co.*	$10,150	No date given.
2	Wisconsin Bridge and Iron Co	12,740	Sept. 1, 1892.
3	Grant Wilkins	14.474	Nov. 1, 1892.
4	King Bridge Co	13,998	Aug. 1, 1892.

* Informalities in proposals.
All proposals recommended for rejection, prices being deemed excessive.

REPORT OF MR. R. R. JONES, ASSISTANT ENGINEER.

LOUISVILLE, KY., *June 30, 1892.*

COLONEL: I have the honor to submit the following report of operations for the care of the Louisville and Portland Canal for the fiscal year ending June 30, 1892:

DREDGING IN CANAL.

The United States towboat and two dredges have been engaged in the removal of mud from the canal and approaches. One of the dredges was partly employed in the removal of the old canal wall and backing, at the new basin just above the new locks. The stone was taken out on the bank for future use and the earth in part used for backing up the new wall.

UNITED STATES TOWBOAT AND DREDGES.

The United States towboat was repaired, the pilot house raised about 4 feet, and the cabin extended forward under the pilot house, adding a very desirable room to the cabin. This work included a new canvas covering to roof.

The dredges were repaired as usual by replacement of spuds and dipper handles as they became broken. The canvas covering of Dredge No. 1 was replaced by new. Slight general repairs to machinery.

DRY DOCK.

The dry dock has been used by outside parties for the purpose of repairing steamboats, barges, etc. Six steamboats and barges have used the dock for a period of 13 days and 13 hours, paying therefor the sum of $165.42. The season was a very short one owing to the building of new wall alongside dry dock, which, while it was in progress, prevented the use of the dock.

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NEW MIDDLE GATES.

These gates were completed during the season of 1891 and were allowed to remain upon the ways until the high-water season occurred in the spring, when they were successfully launched April 23, 1892. Since this time they have been floating in readiness to erect in place at such a time as will least interfere with navigation.

ANCHORS AND GUY RODS, MIDDLE GATE COLUMNS.

The anchors which secured the guy rods used to stay the suspension columns had been pulling loose from the masonry, in which they were embedded to a depth of but 7 feet. A new system of anchorage has been put in, consisting of bars 3½ inches diameter, extending 20 feet down into the masonry of lock walls. These anchors, six for each column (one more than the old system), were placed in holes drilled through the masonry to the depth named, and cemented therein with English Portland cement.

The lower end of anchor bars have stout heads 2 inches larger in diameter than the body of bar. The upper ends have carefully forged eyes through which pass stirrup bolts 2½ inches diameter, with cross bars, connecting with the guys, which run to the top of the column.

The entire system of anchorage was successfully completed without interfering with the use of the gates and holds perfectly firm and secure.

REPAIRS TO LOCK GATES.

Repairs were made to the upper, middle, and lower gates of the new locks as occasion demanded. Nine cast-iron wickets, or valves, were replaced and three bearings for same were put in place. The replacement of the latter was a very troublesome operation, involving the use of a partly submerged dock, in which the men worked. A number of the truss rods were also replaced when broken.

PAINTING.

The engine houses and portions of the gates and iron work were painted.

TRIMMING CANAL WALL.

This work was continued during the year whenever the water was sufficiently low. The season for such work is necessarily very short, as the most troublesome ledges are only exposed during a very low stage of water in the river, and then for but a brief period.

The manner of conducting this work was the same as in preceding years, viz, by stonecutters dressing the stone while working from flats.

BRIDGES.

Repairs were made to the flooring and stringers of bridge at new locks and temporary repairs to lower chord of bridge at old locks.

The bids received for construction of a new iron drawbridge at new locks having been unsatisfactory, all bids were rejected, and a new opening of bids will become necessary.

The old wooden drawbridge at old locks is in a very insecure condition, and the temporary repairs alluded to above will only suffice to carry the bridge along for a few months, within which time a new structure should be erected.

SHOPS AND OTHER BUILDINGS.

A fire, which occurred on the evening of February 12, destroyed the frame building used for boiler and engine house and machine shop. The origin of the fire was unknown. The city fire department and the regular canal force, with our own fire apparatus, succeeded in confining the fire to the building in which it originated. The building was entirely destroyed, and the shafting, pulleys, and machinery more or less injured. The work of rebuilding in stone was commenced within a short time after the fire, and the engine and boiler houses are now completed. The entire structure will be in shape like two Ls joined together—the boiler and fuel rooms, 18 by 44, constituting one L; the machine shop, 26 by 50, another L, and the two united by the engine room, 14 by 18. The fuel rooms are rendered fireproof by brick arches sprung between 7-inch iron I-beams. The exhaust fan, for conveying shavings from

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planing mill to fuel room, is located directly above this fireproof floor. The roof of boiler and engine rooms is entirely of iron, both trusses and roof covering.

The roof of machine shop will have corrugated-iron covering laid on wooden trusses. The floors throughout are of concrete. The stone used in the walls of these buildings was taken up by the dredges from old canal walls and dressed as required.

A new stationary engine was purchased, and also a heavier line of shafting for furnishing power to the planing mill. This shafting crosses the roadway on a bridge 30 feet long.

REPAIRING MUD SCOWS.

The timber and iron work has been purchased for repairs to the two remaining old mud scows. These boats have been pulled out on the ways, stripped, and the work of rebuilding commenced.

The fire, which disabled the engine used for running planing mill, has retarded the dressing of lumber, but this cause of delay will soon be removed.

Very respectfully, your obedient servant,

R. R. JONES,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Statement of vessels passed through the Louisville and Portland Canal during the fiscal year ending June 30, 1892.

Vessels.	Number.	Tons capacity.
Passenger boats	605	248,460
Towboats	1,008	122,644
Government boats	143	12,523
Coal boats and barges	4,065	1,170,751
Small craft	201	.....
Rafts	7	.....
Total	6,029	1,554,377

Lockages, 3,600.

Statement of commerce passed through the Louisville and Portland Canal during the fiscal year ending June 30, 1892.

Articles.	Tons.	Articles.	Tons.
Coal	1,232,998	Iron ore	12,821
Salt	7,448	Steel rails	26,493
Oil	2,089	Iron manufactured	104,410
Whisky	1,619	Produce	9,219
Tobacco	3,850	Flour	844
Cotton	8,559	Sugar and molasses	6,761
Lumber	67,248	Hay and straw	5,665
Corn	9,895	Live stock	5,242
Wheat	7,567	Cement	1,453
Miscellaneous	106,405		

Total tons, 1,620,586.

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E E 4.

IMPROVEMENT OF WABASH RIVER, INDIANA AND ILLINOIS.

The improvement of this stream has of late years been carried on under two distinct appropriations, one applicable to improvements above and the other below Vincennes, Ind. Excepting the construction of a lock and dam to pass the Grand Rapids, near Mount Carmel, Ill., operations on the two sections are of the same nature. With the appropriations complete for finishing this lock and dam, operations would be facilitated by consolidating the two appropriations in one for the future. The aim in both cases is to secure a navigable low-water channel of 3 feet, and to this end it is necessary to excavate channels through rocky reefs and gravel bars, to concentrate the flow by properly located dams, to protect the shores from wash at some points, and to clear the river of snags.

IMPROVEMENTS BELOW VINCENNES.

The principal work on this section during the past year was on the lock and dam near Mount Carmel. At the beginning of the year the masonry of the lock, excepting the shore wall, had been about completed, but no work had been done on the dam. During the past fiscal year the shore wall was completed, miter sills secured in positions, gates and valves built in place, earth filling placed and graded behind the shore wall, and all structures auxiliary to the work of construction removed. But little remains to put the lock in working order besides setting up the maneuvering apparatus for the gates.

In the meantime all preparations for building the west abutment of the dam were made, and, the material having been delivered, the work of construction was commenced September 25 and completed November 15, 1891.

The work done on the lock during the year comprised the laying of 1,442 cubic yards of masonry; 4,676 cubic yards earth were hauled and embanked behind the lock wall, and 1,554 cubic yards of mud and débris removed from the lock chamber. The total masonry in the lock is 7,532 cubic yards, and the whole work is of a most substantial and excellent construction. Work on the abutment of the dam comprised excavating 1,520 cubic yards of earth, laying 655 cubic yards of masonry, and embanking 1,100 cubic yards of earth against the abutment.

In addition to this permanent work at Mount Carmel the snag boat Richard Ford was employed up to December 1 in removing snags between that point and the mouth of the river, principally in the vicinity of Grayville, New Harmony, Little Chain, and Black's Cut-off. At the last-named points the accumulation of snags was such as to establish a complete blockade. The crib dike at Little Chain was repaired and filled with stone; 429 snags, weighing in all 1,786 tons, were removed. The result of this work has been to materially improve the navigable condition of this portion of the river; but there remains a number of shoals, where, at low water, a navigable depth of only 15 or 18 inches exists. The worst place is at New Harmony, where, by the destruction of a dam which formerly closed the cut-off at that place, the channel depth has been reduced to 12 inches at low water, instead of about 2½ feet, as was the case when the river was held to a single channel. The reconstruction of the dam is of great importance,

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but to make the improvement permanent will require an expenditure of not less than $15,000.

The principal work contemplated during the year had been the completion of the dam at Mount Carmel, thereby restoring navigation beyond the rapids at that place; for until this is done no use can be made of the new lock. It is now thought that it will be impossible to do this during the present season because of the late date at which the new appropriation for the work will become available; but all the material for the work can be accumulated, and had in readiness for rapid construction during the next low-water season. It is further proposed to do some snagging on this section of the river, and, if sufficient funds be available, to restore the channel at New Harmony.

For opening proper channels through the various shoals and for shore protection, dikes, and dams it is estimated that an expenditure of $40,000 would result in greatly improving navigation on this section of the river.

The inclosed report of O. L. Petitdidier gives somewhat more in detail the operations of the year, and supplies certain commercial statistics for this portion of the river. It appears from these that the commerce for the past year was about 60,875 tons, mainly grain and lumber, valued at about $812,500.

Money statement.

July 1, 1891, balance unexpended	$41,800.77
June 30, 1892, amount expended during fiscal year	34,886.36
July 1, 1892, balance unexpended	6,914.41
July 1, 1892, outstanding liabilities	434.68
July 1, 1892, balance available	6,479.73
Amount appropriated by act approved July 13, 1892	60,000.00
Amount available for fiscal year ending June 30, 1893	66,479.73
Amount (estimated) required for completion of existing project	40,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	40,000.00

Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. O. L. PETITDIDIER, ASSISTANT ENGINEER.

MOUNT CARMEL, ILL., *June 30, 1892.*

COLONEL: I have the honor to present the following report on the improvement of the Wabash River, Indiana and Illinois, below Vincennes, for the fiscal year ending June 30, 1892.

The work carried on during the last fiscal year has consisted of continuation of work at the lock, construction of a masonry abutment for the dam, and the removal of snags between Vincennes and the mouth of the river.

LOCK AND DAM AT GRAND RAPIDS.

Lock.—The work done at the lock has consisted of completion of masonry of land wall, thus completing the masonry work; construction and erection of gates and valves for filling and emptying culverts; filling and grading of bank behind land wall, and cleaning a large quantity of mud and other débris from the lock chamber. In addition to this the service and traveler tracks were torn down and put away.

The lock itself, including gates and valves for filling and emptying culverts is now completed, there remaining to be done only the crib-work walls at the head and foot of lock, dredging portions of cofferdam, and cleaning of the balance of débris still unremoved.

The lock gates are built of white oak throughout, and are constructed without separate heel or toe posts, the transverse timbers reaching from heel to toe.

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The filling and emptying of lock chamber is done solely through the lock walls and masonry miter sill. The valves for opening and closing are of cast iron and of the style known as butterfly valves.

There being no probable great demand on the lock, each gate is opened and shut by means of a capstan, line, and spar. It is thought that this will be amply sufficient.

I append the following data relative to the lock:

	Cubic yards.
Masonry laid during the fiscal year	1,442
Masonry laid previously reported	6,090
Total masonry laid in construction of lock	7,532
Earth hauled and spread behind land wall of lock	4,676
Mud and débris excavated from lock chamber	1,554
Approximate cost of 4 lock gates and valves	$7,870

The voussoirs forming the arch of lower miter sill were bolted down to the bed rock with 48 bolts 1¼ inches diameter and 5 feet long.

Abutment.—The stone for construction of abutment was furnished by the Romona Oölitic Stone Company, the whole amount contracted for being delivered by October 1, 1801.

The work of erecting derricks and building of storehouse for cement and tools had been going on, and as soon as stone was all received the work of excavation for foundation was begun with great vigor.

Considerable trouble was experienced in going to the bed rock on account of quicksand and the loess or drift next to the rock. A small cofferdam was found necessary, and the expense of foundation thereby increased. Work was begun September 25 and completed by November 15, 1891.

The abutment consists of a masonry wall 10 feet thick at the bottom, 7 feet at the top, and 20 feet high; the face of wall at right angle to the dam proposed, line of dam being smooth finished to the height of proposed dam, the face of remainder and both wings being finished with quarry-face masonry.

I append the following data pertaining to the abutment:

	Cubic yards.
Masonry in abutment	655
Excavation for foundation	1,520
Earth hauled and spread behind abutment	1,100
Approximate cost of stone, including inspection	$7,229.11
Approximate cost of laying masonry, including excavation, supplies, fuel, sand, broken stone, and cement	2,965.18
Total	10,194.29
Approximate cost per cubic yard for laying stone, including all expenses as per above	4.53

REMOVAL OF SNAGS.

In accordance with the project the snag boat *Richard Ford* was employed in removing a large number of snags between Mount Carmel and the mouth of the river.

Many dangerous snags were removed between Grayville and New Harmony, but by far the largest number were removed at Little Chain and Black's Cut-Off, where the number of snags had accumulated to such an extent as to shut off the channel at low water. These places were almost entirely cleaned out. During some two weeks while the river was at the very lowest stage the crew of the snag-boat was employed in repairing and building new cribs in the dike at Little Chain and removing many cubic yards of loose rock which had rolled into the chute.

The snag-boat returned into winter quarters on December 1st, remaining at Mount Carmel until June 25th, when she was sent to Vincennes to remove snags on the Wabash River above Vincennes.

The work done by the snag-boat was as follows:

Number of snags removed and destroyed	429
Weight of snags removed and destroyed ..... tons	1,786
Number of days repairing cribs at Little Chain	10

CONDITION OF THE RIVER.

The removal of snags during last season has undoubtedly been of great benefit to the navigation, but nevertheless, the river, at very low water, is not practicable for boats drawing over 15 to 18 inches of water, except in a few places where deep pools obtain between shoals.

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The worst impediment to navigation outside of the Grand Rapids at Mount Carmel is at New Harmony, where a cut-off, at one time shut off by a dam, drains over half of the water of the main river, which could formerly be navigated at low water by boats drawing 24 to 30 inches of water, is now impassable at a corresponding stage by boats drawing 12 inches.

The portion of river thus deprived of navigation is 12 miles in length.

As the island which is now between the cut-off and the main river is overflowed at high water and is composed of a sandy soil of very loose nature, it does not seem possible to devise any sort of closing for the cut-off which would last more than one season, and this in the present enlarged size of the cut-off would be very expensive.

At Grayville Bend Cut-Off.—Where an examination was made a few days ago, the levee built by the United States is still in good order, while the spur dikes have accomplished what was expected of them. At this place the banks are very friable and it is probable that some additional work of protection will be necessary before long.

At Grand Rapids.—Near Mount Carmel, Ill., where the greatest obstruction exists, no benefit can of course be expected until the improvement, consisting of lock and dam, is completed.

Taken all in all, at very low water, navigation is suspended, not that the improvements built by the United States are necessarily inefficient, but that the amount of water in the river seems either to diminish or the reefs seem to build up during the periods of low water, which grow longer as the drainage of the river basin becomes more perfect.

PROJECT.

During the present fiscal year it is contemplated to complete the hull of new snagboat and resume removal of snags. Should any new appropriation for the lock and dam become available during the present fiscal year, it would be proposed to enter into contract for the timber for dam to be delivered during next winter and spring; in the meantime we could quarry during the present summer some 11,000 cubic yards of rubble stone which will be needed for the dam. This stone could be piled on the river bank and transported during the high water of 1893, and thus having timber and stone on hand no delay would be experienced in the construction of dam.

The lock and abutment already built are useless until after completion of the dam.

I forward herewith the commercial statistics of the river below Vincennes, also comparative statistics of the whole river, for the past six years. It will be seen that considerable increase in the tonnage has taken place while the increase in value of freight has nearly doubled; this difference being due to greater proportion of grain to total tonnage.

The increase of commerce is principally due to the high water prevailing during the last three months.

Very respectfully submitted.

Your obedient servant,

O. L. PETITDIDIER,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

List of steamboats and barges plying on Wabash River, below Vincennes, during the fiscal year ending June 30, 1892.

Name.	Kind.	Tonnage of boat.	Tonnage of barge.	Total tonnage.	Where plying.
Emma Cooper and 5 barges	Towboat			750	Occasional trips.
Eugene and 5 barges	do			750	
E. S. Ragon	Stern wheel				
J. P. Droulliard	do				
John Fowler	do				
Emma Evans and 4 barges	do				
Rosedale and 3 barges	do	147	385	532	
Alex Perry	do				
D. A. Nesbit and 6 barges	Towboat		1,450	1,450	
Cumberland and 1 barge	Stern wheel	400	80	480	Grayville to Mount Carmel.
Irene and 2 barges	Side wheel	60	60	120	Mount Carmel and White River.
Peankishaw and 1 barge	Stern wheel	53	76	129	Mount Carmel to Vincennes.
Diana and 2 barges	do	60	50	110	White River and Terre Haute.

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Statement of commerce, Wabash River, below Vincennes, for fiscal year ending June 30, 1892.

Articles.	Tons.	Approximate value
Grain	35,635	$659,247.50
Lumber and logs boated and rafted	25,250	153,200.00
Total	60,885	$812,447.50

Comparative statement of commerce, Wabash River, above and below Vincennes.

Years.	Tons.	Approximate value.
1887	122,729	$1,817,947.00
1888	58,014	535,006.00
1889	106,513	1,573,698.00
1890	100,443	641,107.00
1891	103,415	1,162,299.00
1892	122,535	2,037,242.40

IMPROVEMENTS ABOVE VINCENNES.

It was the intention at the beginning of the year to clear a number of snags from this section of the river, but it was found impracticable to make any suitable arrangements for doing the work. The snagging outfit owned by the Government was totally unserviceable, and no proper plant for doing the work could be obtained from private parties on satisfactory terms; as a result no work was done.

Towards the close of the year the snag boat *Richard Ford*, which was at work on the lower river during the last season of operations, was sent up to Vincennes, and will be kept at work above that point during the ensuing season. In the meantime a new hull for the steamer *Osseo* is in process of construction and will be fitted for snagging purposes; when completed it will be an easy matter, with the two boats, to keep the entire river clear of snags with annual appropriations of about $5,000 for the operation of each boat.

Besides the removal of snags an additional expenditure of about $20,000 would be of great benefit to navigation on this section; it is needed for opening channels through the worst shoals, the construction of dams for a proper concentration of flow, and for shore protection in a few localities.

The commerce on this section for the past fiscal year is reported at 61,660 tons of freight, valued at about $1,250,000.

I transmit herewith report of O. L. Petitdidier, assistant engineer, with commercial statistics gathered by him.

Referring to the opinion expressed in the first part of this report, I would invite consideration to the propriety of making a single appropriation of $60,000 for "improving the Wabash River, Indiana and Illinois" for the year ending June 30, 1894, in lieu of separate appropriations of $40,000 and $20,000 for improvements *below* Vincennes and *above* Vincennes, respectively.

Money statement.

July 1. 1891, balance unexpended	$5,742.26
June 30, 1892, amount expended during fiscal year	974.28
July 1, 1892, balance unexpended	4,767.98
July 1, 1892, outstanding liabilities	440.00
July 1, 1892, balance available	4.327.98
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	9,327.98

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Amount (estimated) required for completion of existing project.....	$15,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	15,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. O. L. PETITDIDIER, ASSISTANT ENGINEER.

MOUNT CARMEL, ILL., *June 30, 1892.*

COLONEL: I have the honor to submit the following report upon the improvement of the Wabash River above Vincennes during the fiscal year ending June 30, 1892:

The plan of operations contemplated at beginning of fiscal year consisted of the removal of numerous snags which were obstructing the channel between Vincennes and Terre Haute, a distance of 90 miles.

As the steamer *Osseo*, which had been used formerly in towing the snag boat, had become entirely unserviceable, an effort was made to secure the services of a towboat to take its place, but owing to unacceptable restrictions put on by the owner of towboat the offer could not be accepted.

It was determined to build a new hull and fit it up with machinery of the *Osseo* and the snag scow, thus giving us a more manageable single snag boat and avoiding the necessity of employing a double crew as formerly.

In continuation of this plan the necessary timber was ordered early in the spring of 1892, and work was begun as soon as stage of water was such as to uncover the low bank which was to be used as a shipyard.

The long-continued high water of the spring of 1892, lasting nearly three months, having delayed the building of new hull until it was found that the new boat would be prevented from passing over the Grand Rapids near Mount Carmel before low water set in, the snag boat *Richard Ford* was sent up to Vincennes, and is at this date in readiness for the work of removing snags between Vincennes and Terre Haute.

Condition of river.—The condition of the river remains unchanged since last year's report, the snags still forming at low water a very great obstruction to navigation.

The commerce is still considerable, and, as will be seen by the commercial statistics here appended, shows a very decided increase over the previous year. This is mainly due to the long-continued high water of this spring, which has been very favorable to navigation.

Project.—During the present fiscal year it is intended to resume snagging operations and push work vigorously until funds on hand are exhausted.

I forward herewith tabular statements showing amount of freight carried on this part of the river during the past fiscal year.

Very respectfully submitted.

Your obedient servant,

O. L. PETITDIDIER,
Assistant Engineer.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Statement of commerce, Wabash River above Vincennes, for fiscal year ending June 30, 1892.

Articles.	Tons.	Approximate value.
Grain	55,204	$1,026,794.40
Lumber	875	14,250.00
Stave bolts	600	1,440.00
Salt	373	2,734.00
Wood	926	521.00
Shingles	600	262.00
Merchandise	2,850	147,500.00
Stock	232	13,890.00
Total	61,660	1,207,391.40

Passengers, 17,404.

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List of steamboats and barges plying on Wabash River above Vincennes during the fiscal year ending June 30, 1892.

Name.	Kind.	Tonnage of boats.	Tonnage of barges.	Total tonnage.	Where plying.
Rosedale and 3 barges	Stern wheel	147	385	532	Terre Haute and Ohio River.
Jamie Ray and 2 barges	do	100	220	320	Terre Haute and Vincennes.
Peankishaw and 1 barge	do	53	76	129	Terre Haute, Vincennes, and White River.
Cumberland and 1 barge	do	400	80	480	Grayville and Terre Haute.
Diana and 2 barges	do	60	50	110	Terre Haute, Vincennes, and White River.
J. H. Russell	do				Above Terre Haute.

E E 5.

IMPROVEMENT OF WHITE RIVER, INDIANA.

The object heretofore in view on this river has been to create channels through rocky chains and sandy shoals such as to render the stream navigable for light-draft boats at low water, but with appropriations limited as they have been it is not practicable to do much more than keep existing channels clear of snags.

During the past year operations were confined to improving the channel through Kellys Ripple, near the mouth of the river; to this end a guiding dike 350 feet long was constructed to connect the south dike of channel with the adjoining river bank and facilitate entrance to the channel formerly excavated through the reef. Owing to the extreme low water that prevailed throughout the working season it was not possible to employ the snag boat, as had been proposed.

It is proposed during the coming season to remove the worst snags which now interfere with navigation at ordinary stages. A low-water navigation under present conditions is not practicable, nor can it be made so without a large expenditure. Under the circumstances about all that can be done for the benefit of navigation on this stream is to keep existing channels reasonably free from obstructions. No estimate for a radical improvement of this river has been prepared nor any survey made on which one might be predicated. An estimate of $5,000 for the year ending June 30, 1894, is submitted, which would be applied mainly to the removal of snags.

The report of O. L. Petitdidier, assistant engineer, herewith transmitted, shows a commerce during the last year of 23,130 tons, valued at $174,000.

Money statement.

July 1, 1891, balance unexpended	$5,175.32
June 30, 1892, amount expended during fiscal year	2,220.53
July 1, 1892, balance unexpended	2,954.79
July 1, 1892, outstanding liabilities	4.75
July 1, 1892, balance available	2,950.04
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	7,950.04
Amount (estimated) required for completion of existing project	7,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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REPORT OF MR. O. L. PETITDIDIER, ASSISTANT ENGINEER.

MOUNT CARMEL, ILL., *June 30, 1892.*

COLONEL: I have the honor to present the following report of work done on the White River, Indiana, during the fiscal year ending June 30, 1892:

The work intended to be done at the beginning of the fiscal year consisted of the completion of improvement at Kellys Ripple and removal of snags from the channel.

Owing to the very low stage of water prevailing on the Wabash River during the whole summer, it was found impracticable to take the snag boat *Richard Ford*, with which it had been intended to remove snags, up to White River, so that the work done was confined to completing the improvement at Kellys Ripple.

The work done at this place has consisted of the construction of a guiding dike 350 feet long, 10 feet wide, and 5 feet high, from the head of the south dike to the left bank of river; the widening of entrance of chute for a distance of 150 feet, and rebuilding for a distance of 240 feet, of the north dike, which had suffered badly since its construction.

I append the following data in regard to the work done:

Linear feet of logs used	11,570
Linear feet of driftbolts used	1,871
Cubic yards of stone filling used	990
Approximate cost of work	$2,163.06

Work was begun on July 16 and continued until its completion, October 22, 1891.

The improvement, as completed, is now of great assistance to navigation.

Condition of river.—With the exception of Kellys Ripple, where the improvement has been completed, the condition of the river is no better than reported last year; numerous snags render navigation difficult and dangerous, while in places the caving and cutting of banks brings in fresh obstructions; such a place is Thorns Eddy, three-fourths of a mile above Deckers, where a row of piling which had been driven to protect the bank is now by reason of successive erosion behind it, in the middle of the channel, and the obstruction most complained of by steamboat men.

The bridge at Rodgers is still unprovided with a draw, but no complaint has been heard in regard to it, there being no navigation in this portion of the river.

Project.—It is intended during the present year to resume the removal of snags and obstructions as soon as practicable, and until the present funds on hand are exhausted.

Should any additional funds become available during the present fiscal year, the work of snagging could be continued through the whole season.

I append commercial statistics for the present fiscal year, also comparative statistics for the five years previous. It will be seen that there has been quite an increase in the commerce of the river; this has been mainly due to the favorable stage of the river during the last three months.

Very respectfully submitted.

Your obedient servant,

O. L. PETITDIDIER,
Assistant Engineer.

Lt. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Statement of commerce, White River, Indiana, fiscal year ending June 30, 1892.

Articles.	Tons.	Approximate value.
Grain	4,630	$90,000
Logs and lumber, boated and rafted	18,500	84,000
Total	23,130	174,000

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Comparative statement of commerce, White River, Indiana.

Years.	Tons.	Approximate value.
1887	12,650	$181,000
1888	6,400	71,145
1889	27,000	137,950
1890	29,409	256,330
1891	15,632	93,150
1892	23,130	174,000

List of steamboats plying on White River, Indiana, during the fiscal year ending June 30, 1892.

Name.	Kind.	Total capacity.	Where plying.
		Tons.	
Diana and 2 barges	Stern wheel	110	Hazleton to Vincennes.
Irene and 2 barges	Side wheel	120	Mount Carmel to Hazleton.
Peankishaw and 1 barge	Stern wheel	129	Occasional trips.
Emma Cooper and barges	Towboat	150	Do.

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APPENDIX F F.

IMPROVEMENT OF GREAT KANAWHA, ELK, AND GAULEY RIVERS, WEST VIRGINIA, AND OF NEW RIVER, VIRGINIA AND WEST VIRGINIA.

REPORT OF COL. WM. P. CRAIGHILL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Great Kanawha River, West Virginia.
2. Operating and care of locks and dams on Great Kanawha River, West Virginia.
3. Elk River, West Virginia.
4. Gauley River, West Virginia.
5. New River, Virginia and West Virginia.

(For letter of transmittal see Appendix I.)

F F 1.

IMPROVEMENT OF GREAT KANAWHA RIVER, WEST VIRGINIA.

The object of the improvement has been to give a depth of not less than 6 feet all the year round throughout the whole river, 96 miles. The means are locks and dams. The locks are about 300 by 50 feet, above Charleston, and about 340 by 55 feet below. The following table shows the present condition:

No.	Distance in miles from Charleston.	Style of dam.	Completed in—	Remarks.
2	26 miles above	Fixed	1887	In operation.
3	21 miles above	do	1882	Do.
4	15 miles above	Movable	1880	Do.
2	9 miles above	do	1880	Do.
6	4 miles below	do	1886	Do.
7	14 miles below	do		Lock finished and dam under contract.
8	22½ miles below	do		Do.
9	32 miles below	do		Site purchased September, 1890.

Two more sites will require to be occupied below No. 9. Some dredging is also necessary in some of the pools, as well as the occasional removal of snags and rocks.

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Locks 7 and 8 were completed in 1892, as well as parts of the foundations of dams 7 and 8. When these two locks and dams are added to the finished works there will be a very great gain in the availability for navigation at all seasons on the river.

Mr. A. M. Scott has continued to exercise the local charge in his usual efficient manner. His report, which is appended, treats in detail of the operations of the year.

As the improvement of the river has progressed the commerce on it, notably the shipment of coal, has greatly increased.

The telephone line has been maintained between the central office in Charleston and the locks, and it is used by night as well as by day, being found indispensable for the proper oversight and direction of the operations, as well of construction and of maintenance.

A gauge-reader has been kept at Kanawha Falls, near which place the Gauley joins the New to form the Kanawha River; and another at Hinton, where the Greenbrier empties into the New River. The compensation of these men is less than $10 a month each. They send to the central office daily reports, by postal cards, of the stage of the river at their respective stations and by telegraph when there is a rapid rise. These reports are necessary as warnings to the central office in Charleston, in order that such maneuvers of dams, etc., may be had in time as the height and duration of the freshets may require.

For perfect security a similar station should be occupied at some point on the Upper Gauley, and perhaps also on the Elk.

The following are the amounts and dates of appropriations for improving Great Kanawha River, West Virginia:

March 3, 1873	$25,000.00	August 2, 1882	$200,000.00
June 23, 1874	25,000.00	July 5, 1884	200,000.00
March 3, 1875	300,000.00	August 5, 1886	187,500.00
August 14, 1876	270,000.00	August 11, 1888	350,000.00
June 18, 1878	222,000.00	September 19, 1890	300,000.00
March 3, 1879	150,000.00		
June 14, 1880	200,000.00	Total	2,629,500.00
March 3, 1881	200,000.00		

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 8, 1892.

GENERAL: The estimate for the project for the improvement of the Great Kanawha by the method of locks and movable dams was prepared in 1875, seventeen years ago.

Several circumstances seem to make the present a suitable time for its final revision. A revised estimate is therefore submitted below. One reason why this has not been done sooner was the hope that in the project for the Ohio it might be known whether it was likely a dam would be built below the mouth of the Kanawha near enough to raise the water to such a distance as to influence the location of the dams in the Kanawha near its mouth and thus perhaps save the expense of one site in the Kanawha.

In a letter of September 26, 1891, from Col. Merrill he says: "I would therefore advise you to make your location on the Great Kanawha River without regard to what may be done on the Ohio."

The original estimate amounted to $4,000,000. The appropriations since have amounted to $2,579,500.

This would leave a sum of $1,500,000 to be still provided if the original estimate were adhered to, but reasons have arisen for changing it. In four or five years it became apparent that the upper dam of the series estimated for would not be necessary, as the commerce above the pool of No. 2 would not justify so large an expenditure as the occupation of Site 1 would have required.

When the original estimate was made it was necessarily founded on French drawings and experience, as a movable dam of the Chanoine type had not been built in America. The knowledge of the river since gained by our own experience and more detailed surveys than the hurried ones upon which the first estimates were based has also been great. We have thus been enabled to rearrange the locations of the sites

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to be occupied and to omit another of the twelve locks and dams originally provided for. For these considerations the estimate was reduced by $600,000 in 1878.

The amount asked for in the last Annual Report for completion of the work in the occupation of ten sites was $670,000. The following revised estimate was lately made with great care by Mr. A. M. Scott, the resident engineer at Charleston:

"COLONEL: In compliance with your instructions I have the honor to submit below an estimate for completing the Great Kanawha slack-water improvement to the mouth of the river:

For Lock and Dam No. 9, complete, not including inspection, engineering, office expenses, etc	$320,000
For Lock and Dam No. 10, complete, not including inspection, engineering, office expenses, etc	325,000
For Lock and Dam No. 11, complete, including purchase of site, not including inspection, engineering, office expenses, etc	485,000
Amount required to complete locks and dams Nos. 7 and 8, in addition to money now available	15,000
For additional lock houses at locks Nos. 2, 3, 4, 5, 6, 7, and 8, sixteen houses in all	12,000
Dredging in pools at heads of shoals and for lock approaches	30,000
	1,187,000
For inspection, engineering, general office expenses, and incidentals, 10 per cent	118,700
Total	1,305,700

"The cost of No. 11 over 9 or 10, or either of the other locks and dams on the river, is due partly to the greater width of the river at No. 11 (being from 100 to 210 feet wider than at the other sites), but more to the greater depth of foundations. The bed rock at 11 and in that vicinity is about 18 feet below low-water mark, and the foundations will average from 6 to 10 feet deeper below sills than at any of the other sites, increasing materially the quantities of masonry, concrete, excavation, and expenses of cofferdams.

"The estimate submitted is regarded as a 'full estimate,' and it is believed the actual cost of the completed works will be made to fall below it. It was thought advisable, however, to make the estimate large enough to cover considerable uncertainty, unavoidably connected with such works.

"Col. WM. P. CRAIGHILL,
"*Corps of Engineers.*"

The cost of what has been done is considerably greater than it would have been if the work had not been protracted through so many years instead of being entirely finished in three, as it might have been had money been available. The whole work could have been done in the same time as at each site, and three years is a full allowance of time for any site.

Moreover, the size of the locks has been increased by proper authority beyond what was originally proposed.

Work is nearly completed at sites 7 and 8. The completion of No. 8 marks an unusually important step in the improvement of this river, which has been a success from the commercial as well as the engineering point of view.

When the dam of No. 8 is finished, boats can at all times come as low as its pool for a harbor, and when there are often within reach of the back water of the Ohio in its freshets which may be in progress when the Kanawha is not.

Under such circumstances the coal, etc., from the Kanawha may at once pass over the unimproved lower part of that river and down the Ohio to a market at Cincinnati and the other great cities on the Ohio and Mississippi rivers and their dependencies by water and rail.

Moreover, should the backwater from the Ohio not come fully to the pool of Dam 8, it is thought it may at times be supplemented by using the water of pool 8 and others above it to flush the portion of the Kanawha below 8 sufficiently to enable boats to reach the Ohio at some stages when such movement would otherwise be impossible, when there would be a boating stage in the Ohio and not in the Kanawha.

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Two tables are added below which may be of interest:

Tables showing the location, etc., of locks and dams on the Great Kanawha River, already completed, now building, and yet to be built.

Number of lock and dam.	Location.	Kind of dam.	Remarks.
2	1 mile below Cannelton and 84½ miles from mouth of river	Fixed...	Finished in 1887.
3	1 mile below Paint Creek and 79½ miles from mouth of river ..	....do ...	Finished in 1882.
4	1½ miles below Coalburg and 73 miles from mouth of river	Movable	Finished in 1880.
5	9 miles above Charleston and 67½ miles from mouth of river...	....do ...	Do.
6	4½ miles below Charleston and 54 miles from mouth of river...	....do ...	Finished in 1886.
7	1½ miles below St. Albans and 44 miles from mouth of river...	....do ...	Nearly completed.
8	2½ miles below Raymond City and 35¾ miles from mouth of river.	....do ...	Do.
9	6 miles below Winfield and 26 miles from mouth of river.....	....do ...	Not begun yet. The site owned by United States.
10	2¾ miles below Buffalo and 18½ miles from mouth of river	....do ...	Not begun yet.
11	Foot Three Mile Bar and 1¾ miles from mouth of river.....	....do ...	Do.

Number of lock and dam.	Width of lock chamber.	Length of lock between quoins.	Lift.	Style of dam.	Total length of dam.	Approximate average height of dam from bed rock to crest or top of wickets.	Bottom width of fixed dams.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
No. 2.....	50	308	12	Fixed.....	524	26	33
No. 3.....	50	311¾	12	....do	564	24	38

Description of dams.—No. 2. Timber-crib dam filled with stone. Front or downstream face, vertical up to 2′ 9″ above lower pool, then stepped in two steps; bottom step, 5′ 3″ high and 16 feet long; top step, 4 feet high and 11 feet long. Back of dam, vertical to within 3 feet of top, then sloped 3 feet vertical to 11 horizontal.

No. 3. Timber-cribbed, filled with loose stone. Front, vertical to within 4 feet of top, then sloped 4 feet vertical to 16 feet horizontal. Back, vertical to within 6′ 9″ of top, then sloped 6′ 9″ vertical to 17 feet horizontal.

No. of lock and dam.	Width of lock chambers.	Length of lock between quoins.	Lift.	Style of dam.	Length of dam.			Approximate average height of dam from bed rock to crest of top of wicket.
					Navigation pass.	Weir.	Total.	
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*
4.....	50	300	7	Movable.	248	210	458	20
5.....	50	300	7	....do	250	265	515	18
6.....	55	342¼	8¼	....do	248	310	558	21
7.....	55	342¼	8	....do	248	316	564	26
8.....	55	342¼	8¼	....do	248	292	540	17
9 (as proposed).....	55	342¼	6¼	....do	248	*300	*548	18
10 (as proposed).....	55	342¼	7¼	....do	248	*290	*538	18
11 (as proposed).....	55	342¼	9 33/100	....do	248	*420	*668	27

* Approximate.

Dams 4, 5, 6, 7, 8, 9, 10, 11 are of the Chanoine wicket type, operated by trestle-service bridges. Sills of navigation passes from 12½ to 13 feet and sills of weirs from 5 to 9 feet below upper pool levels.

If Congress would be willing to allow contracts to be at once made for the completion of the remaining work in the same way as has been done for the Patapsco and several other localities I think decided advantages would result.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

BRIG. GEN. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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Money statement.

July 1, 1891, balance unexpended		$414,531.40
June 30, 1892, amount expended during fiscal year		206,631.38
July 1, 1892, balance unexpended		207,900.02
July 1, 1892, outstanding liabilities	$4,000.00	
July 1, 1892, amount covered by uncompleted contract	181,469.21	
		185,469.21
July 1, 1892, balance available		22,430.81
Amount appropriated by act approved July 13, 1892		225,000.00
Amount available for fiscal year ending June 30, 1893		247,430.81
Amount (estimated) required for completion of existing projects		1,080,700.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867		

Abstract of proposals for iron work for the movable parts of Dams Nos. 7 and 8, and some extra irons for Dams Nos. 4, 5, and 6, of the Great Kenawha River improvement, opened at the U. S. Engineer office, Charleston-Kanawha, W. Va., at 3 p. m. May 25, 1892.

	Approximate quantities.	No. 1. Fred J. Myers Mfg. Co., Covington, Ky.		No. 2. Snead & Co. Iron Works, Louisville, Ky.		No. 3. New Jersey Steel and Iron Co., Trenton, N. J.		No. 4. H. T. Morrison & Co., Petersburg, Va.	
		Bid.	Amount.	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.
Wrought iron, ...pounds..	495,000	$0.05½	$27,225.00	$0.09 1/100	$45,045.00	$0.07 7/10	$38,115.00	$0.06 1/100	$29,799.00
Cast iron..do..	38,500	0.03¾	1,443.75	0.03 4/10	1,309.00	0.05¾	2,213.75	0.03 4/100	1,412.95
Maneuvering winches.....	2	178.55	357.10	367.00	734.00	272.00	554.00	225.00	450.00
Total.....	.....	.....	29,025.85	.....	47,088.00	.....	40,882.75	.....	31,661.95

Contract with the Fred J. Myers Manufacturing Co.

REPORT OF MR. ADDISON M. SCOTT, RESIDENT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston-Kanawha, W. Va., July 2, 1892.

COLONEL: I have the honor to submit the following report on the Great Kanawha River improvement for the year ending June 30, 1892.

The principal work during the year has been on construction of Locks and Dams Nos. 7 and 8, and in maintaining and operating the five completed locks and dams. The principal works under construction will be given first.

LOCK AND DAM NO. 7—CONSTRUCTION OF.

(Movable dam, 44 miles from mouth of river and 14 miles below Charleston.)

THE LOCK.

The contract, which embraced the lock complete except the lock-gates, was finished in February, 1892. The last piece of coping, completing the mortared masonry, was set December 1, 1891. A general description of the lock, including the coffer-

* $56.38 added. That amount was held in cash, it having been unclaimed by employés who had signed pay rolls. It was deposited as a "repayment" to the appropriation May 18, 1892 in accordance with an opinion of the Second Comptroller of Treasury.

dam and foundations, is given on page 1948 of the Report of the Chief of Engineers for 1889 (in this, owing to a misprint, the length of the lock is given as 141 feet instead of 411, the correct length), and is supplemented on page 2240 of the Report for 1890.

Reference may also be made here to the full detailed drawings (in 14 sheets) with description of this lock and dam,* finished in this office during the year and recently published—photolithographed—by the Chief of Engineers.

The contract above referred to covered, as stated, the lock complete except the gates. It included cofferdamming, pumping and bailing, and the furnishing of all work and all materials except the irons built in the masonry; these irons being furnished by the United States and placed by the contractors. The quantities in and the prices and payments on this contract were as follows:

Grubbing and clearing site	$2,000.00
Crib logs in cofferdam, 53,903 linear feet, at 28 cents	15,092.84
Sheathing in cofferdam, 34,870 feet, B. M., at $30	1,046.10
Filling in cofferdam, 7,361 cubic yards, at 60 cents	4,416.60
Excavation, common, including dredging, 22,387 cubic yards, at 55 cents	12,312 85
Excavation, hard pan, 3,064 cubic yards, at $1.25	3,830.00
Excavation, rock, 11 cubic yards, at $4.80	52.80
Embankment, 11,031 cubic yards, at 50 cents	5,515.50
Puddling, 233 cubic yards, at $1.50	349.50
Concrete, 600 cubic yards, at $5	3,000.00
Concrete below Ref. 530, 2,713 cubic yards, at $6.25	16,956.25
Backing masonry, 5,224 cubic yards, at $4.40	22,985.60
Rock face masonry, 2,017 cubic yards, at $8.60	17,346.20
Pointed face masonry, 1,836 cubic yards, at $9	16,524.00
Cut stone, bush-hammered corners, etc., 351 cubic yards, at $12	4,212.00
Sill, 219¼ cubic yards, at $18	3,946.50
Quoins, 75$\frac{8}{10}$ cubic yards, at $25	1,890.00
Coping, 377¼ cubic yards, at $25	9,437.50
Stone filling in cribs under paving, etc., 3,165 cubic yards, at $1.50	4,747.50
Riprap, hand-placed, 1,987 cubic yards, at $3	5,961.00
Paving, 1,171 cubic yards, at $5	5,855.00
Timber in permanent construction, 60,150 feet, B. M., at $40	2,406.00
Bolt holes drilled in masonry, 1,493 linear feet, at 50 cents	746.50
Amount	160,630.24

The irons built in or attached to the masonry, embracing gate anchorage, line fastenings, pivot-plates, ladders, miter-sill anchorage, and dowels in coping, cost $1,092.75. The lock gates (the irons and timber for which are yet to be procured by contract and the gates built and hung by hired labor) are estimated to cost complete $7,800, making the cost of the lock proper, exclusive of inspection and engineering, $169,523.

DAM NO. 7.

Foundations and masonry.—The foundations and masonry for this movable dam are described generally on pages 2417 and 2418 of the report of the Chief of Engineers for 1891. (They are also fully shown and described in the recently published drawings of Lock and Dam No. 7 above referred to.)

Operations during the year on the contract for this part of the work were mainly directed to building the foundations for part of the navigation pass and in quarrying and cutting stone.

The first section of cofferdam, which embraced 150 feet of the navigation pass next to the lock, was so far completed and pumped out that excavating inside the cofferdam was begun August 7. The placing of the wicket and trestle anchorage began September 8, concreting on the 9th, and the laying of masonry on the 14th. The first timber was placed October 2. The concreting and masonry were completed October 30. The placing of the fixed irons, wicket, and trestle-boxes, sill plates, hurters, slides, etc., was finished November 13, completing the foundations inside this section of the cofferdam.

A bulkhead coffer was built across the outer end of the finished foundations to form the end of the second section of cofferdam. After the completion of the bulkhead about 120 feet of the first cofferdam next to the lock was removed mainly with the dredge. After this, work in the river was suspended for winter.

Operations so far this season have been much delayed by high water. The building of the second section of cofferdam, which is to inclose the remaining 100 feet of the navigation pass, the center pier, and 100 feet of the weir, was begun May 6. This

* Description and Plate I (profile) reprinted herewith.

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cofferdam is now nearly completed. Unless further delayed by high water it will be ready for the pumps the latter part of next week.

The third and final cofferdam will inclose the remainder of the weir and the shore abutment. It is expected that the foundations and masonry of the dam will be completed this season.

Materials prepared.—The contractors have kept good forces in the quarries and stoneyards, and there is likely to be no delay about materials. They now have cut in the yard 1,147 cubic yards of stone, embracing sills, coping, cut stone, rock, and pointed face, being nearly all required for the masonry inside the second section of cofferdam. They have about 1,250 cubic yards of stone broken for concrete and considerable timber on hand.

LOCK AND DAM NO. 8—CONSTRUCTION OF.

(Movable dam, 36 miles from the mouth of the river and 22 below Charleston.)

THE LOCK.

The lock, with the exception of the gates, was completed in February. The last piece of coping, completing the mortared masonry, was set December 19, 1891.

Except in the character and depth of foundations Lock 8 is substantially like No. 7. The bed rock at No. 8 site is found throughout only about 5 feet below low-water mark (about 10 feet higher with reference to low water than at No. 7), effecting a material saving over No. 7, or any of the other locks and dams before built, in the cost of foundations.

The walls are built directly on the rock. The top of the rock was more or less shaly and had to be removed. At the head of the lock the foundations are about 3 feet below level of top of miter sills; except at the head, the bottom or "leveling-up" course is from 8 to 12 inches deep, this being the depth of the foundations below level of top of sills. A somewhat deeper excavation was required to place the sills and pivot stone. Some rock excavation was also necessary in the chamber and under the gates. Concrete was put in between the miter and cross sills and the former anchored to the bed rock by wedge bolts, the same number and arrangement of bolts being used, except that the bolts were shorter, as at No. 7.

The contract completed in February, 1892, covered the lock complete except the gates. It embraced cofferdamning, pumping, and bailing, and the furnishing of all work and all materials except the irons built in or attached to the masonry; these irons were furnished by the United States and placed by the contractor. The quantities in and the prices and payments on the contract were as follows:

Grubbing and clearing site	$100.00
Crib logs in cofferdam, 40,667 linear feet, at 18 cents	7,320.06
Sheathing in cofferdam, 26,300 feet, B. M., at $30	789.00
Filling in cofferdam, 6,085 cubic yards, at 60 cents	3,651.00
Excavation, common, including dredging, 16,144 cubic yards, at 75 cents	12,108.00
Excavation, rock, 1,247 cubic yards, at $5	6,235.00
Embankment, 7,055 cubic yards, at 40 cents	2,822.00
Puddling, 289 cubic yards, at 75 cents	216.75
Concrete, 80 cubic yards, at $6	480.00
Backing masonry, 4,015 cubic yards, at $6.75	27,101.25
Rock face masonry, 1,133 cubic yards, at $8	9,064.00
Pointed face masonry, 1,882 cubic yards, at $10	18,820.00
Cut-stone, bush-hammered corners, etc., 354 cubic yards, at $12.50	4,425.00
Sills, 193 cubic yards, at $18	3,474.00
Quoins, 77 cubic yards, at $26	2,002.00
Coping, 379¼ cubic yards, at $16.50	6,261.75
Stone filling in cribs and under paving, 2,698 cubic yards, at $2	5,396.00
Riprap, hand-placed, 1,665 cubic yards, at $2.50	4,162.50
Paving, 716 cubic yards, at $5.50	3,938.00
Timber in permanent construction, 47,650 feet, B. M., at $38	1,810.70
Bolt holes drilled in masonry, 1,070 linear feet, at 40 cents	428.00
Amount	120,605.01

The irons built in or attached to the masonry, embracing gate and miter-sill anchorage, pivot plates, ladders, line fastenings and dowels, cost $1,055.32. The lock gates, the irons and timbers for which are yet to be procured by contract and the gates built by hired labor, are estimated to cost complete $7,800, making the cost of the lock proper, exclusive of inspection and engineering, $129,460.

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DAM NO. 8.

Work on the contract for building the foundations and masonry of this movable dam (see Report of Chief of Engineers for 1891, page 2419) was directed mainly to building the foundations for part of navigation pass, building the shore abutment, and quarrying and cutting stone.

First cofferdam for pass.—The first section of cofferdam for the navigation pass, inclosing 150 feet of it next to the lock, was completed so that the pumps were started July 9, 1891. Excavation inside the cofferdam began July 13. The blasting of ditches in the bed rock for the anchorage disks and anchor bolts of the wicket sill and service bridge was begun July 20. These trenches are about 8 feet deep. The rock was generally seamy and carried a good deal of water, and some difficulty was met with in keeping the trenches pumped out. The placing of the disks and anchor rods in the trenches and concreting around them was begun August 15, but owing mainly to the small force employed by the contractor was not completed until the 1st of October. The laying of masonry in the pass cofferdam was begun October 8. Operations inside the coffer were stopped November 13 by a rise in the river, and nothing more was done on that part of the work last year. When stopped for winter the condition of the work on this first section was about as follows: The anchorage was in and concreted around; the upper or bridge sill was set; the foundation course under the outer downstream wall was about two-thirds set; the main concreting between the top of the rock and bottom of timbers was nearly finished; the bed sticks were all placed, and sixteen of the main longitudinal timbers were in. The work inside this section of cofferdam should have been finished last season, and would have been without difficulty if the contractor had made proper effort and kept a reasonable force employed. He was carrying on the lock contract, however, at the same time, and seemed unable, or rather unwilling, to keep men and plant sufficient to carry on both works properly.

Shore abutment.—The shore abutment was built last season. Excavation for it began August 13, 1891, and the last piece of coping was set September 25. Some difficulty was met with in making the excavation for the abutment. It is located well back into the bank, and the last 12 or 13 feet in depth (except about 3 feet of gravel on top of the rock) was fine sand, with a good deal of water running in it. The sand caved badly, and it was found advisable to put in curbing, and two rounds of timber and sheet piling were put in clear around the pit before the rock was reached. The loose stone and earth filling back of the abutment—the stone being against the back of the wall and leading to an opening in the lower wing—and the puddle about the upper wing were put in, and the bank riprapped immediately back of the abutment to a height 32 feet above low water. The bank in its unfinished condition stood the winter floods well and has suffered no damage of any importance. The grading and riprapping of the bank on this side will be completed as soon as the retaining crib below the abutment is placed.

Work this season.—Operations on and within the first section of the cofferdam for the pass have been a great deal hindered so far this season by high water. Repairs on the cofferdam, which was considerably damaged during the winter, were begun May 4, 1892. The pumps were started May 12 and excavation inside begun the next day. About 1,675 cubic yards of material—sand, gravel, fine coal, etc.—was found on the work in the coffer dam, deposited by floods during the winter and spring. The cofferdam was flooded May 20 by a rise in the river and pumped out so that work inside was resumed June 14, and has been in progress since then. Unless interrupted again by water the foundations inside this first section of coffer, including the placing of the fixed irons, wicket and trestle boxes, hurters, slides, sill plates, etc., will be completed about July 15, when the end bulkhead will be built (as described under Dam 7), the cofferdam removed, and the building of the second section begun.

Materials prepared.—The contractor has nearly all of the dimension stone, coping, sills, corners, pier recess stone, etc., required for the work, and the greater part of the rock and pointed face cut and on hand. He still lacks about 1,000 cubic yards of rock and pointed face, but the quarries are turning out well and there will be no delay for stone. Considerable trouble has been and is yet being had in getting suitable timber for the wicket sill, box seats, etc., for the pass, but the quantity is small and there is likely to be no material delay on account of it. It is expected that the foundations and masonry of Dam No. 8 will be completed during the present working season.

IRON WORK FOR MOVABLE PARTS OF DAMS.

Drawings for the movable parts of Dams 7 and 8, including the maneuvering winches and eighteen extra trestles for Dams 4, 5, and 6, were prepared during the year. Proposals for furnishing these irons were opened May 25, 1892, and the contract let to the lowest bidder, the Fred J. Meyers Manufacturing Company, of Covington, Ky., by agreement with you dated June 8, 1892, approved by the Chief of

Engineers June 17. The contract covers the service bridge and wicket irons, trestles, aprons, horses, props, small wicket irons, and wicket boxes for the navigation passes and weirs for the two dams and the other irons mentioned above, embracing about 495,000 pounds of wrought iron and 38,500 pounds of cast iron.

The contractors have begun work, but are meeting with delay about getting the formed irons, channels, I bars, etc., on account of the strike now prevailing in some of the large mills. It is hoped the delay will be but temporary.

The fixed irons for these dams, embracing the most of the castings and anchorage, were procured last year. (Report of Chief of Engineers for 1891, pages 2416 and 2429.)

OPERATING COMPLETED WORKS.

Lock No. 2.—Fixed dam; finished in 1887. (Located 85 miles from the mouth of the river and 27 miles above Charleston.)

The lock was in good order and regular operation during the year. Locking was suspended sixty-eight hours in all by high water. The commerce through the lock was as follows:

Coal	bushels	1,277,800
Coke	tons	16,020
Miscellaneous freight, merchandise, produce, etc., by steamboats	do	5,506
Lumber and logs	feet, B. M.	96,800
Coal and coke barges	number	296
Steamboats	do	1,674
Other craft	do	164
Shingles	do	25,000
Brick	do	10,500
Passengers	do	5,938
Lockages made	do	1,766

Riprapping.—High water did some damage to the banks and made it necessary to do considerable additional riprapping; 1,550 cubic yards of stone were used in strengthening and extending the riprap below the works; 850 yards of this were prepared in and boated from the old quarry near the site, the rest being either wheeled or hauled in low stages of water from the bar below the dam. The work was done by the regular lock hands, assisted by some hired labor and teams. The riprapping on the abutment side now extends downstream 1,210 feet and on the lock side 1,370 feet below the crest of the dam.

Lock No. 3.—Fixed dam; finished in 1882. (Located 80 miles from the mouth of the river and 22 miles above Charleston.)

The lock was in good working order during the year. Locking was suspended seventy hours by high water. The commerce through the lock was as follows:

Coal	bushels	1,796,000
Coke	tons	16,020
Miscellaneous freight, merchandise, produce, etc., by steamboats	do	7,148
Lumber and logs	feet, B. M.	477,200
Coal and coke barges	number	429
Steamboats	do	1,682
Other craft	do	70
Shingles	do	55,000
Brick	do	72,000
Passengers	do	8,870
Lockages made	do	1,778

Riprapping.—In addition to the ordinary repairs about the works, 530 cubic yards of new stone were used in repairing and extending the riprapping below the lock and dam; all but 125 yards of this, which were taken from the bar below the dam, was hauled or boated from the old quarry near the site. About 600 yards of old riprap were reset and 425 yards of earth moved in grading the banks. The work was done by the regular lock hands assisted by some hired labor. The riprap on the abutment side now extends downstream 910 feet and on the lock side 1,212 feet below the crest of the dam.

New filling valves.—The working of the new valves put in last year (Report of Chief of Engineers for 1891, pages 2420, 2421) has been entirely satisfactory.

THE MOVABLE DAMS.

The three completed movable dams with their locks were in good working order and regular operation during the year. As usual a good deal was done at each lock and dam, mostly by the regular hands, in keeping the works in order. The most prominent of the repairs are mentioned below under that head. A brief account of the operations at each of the movable dams here follows:

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Lock No. 4.—Movable dam, finished in 1880. Located 74 miles from the mouth of the river and 16 miles above Charleston.

The dam was up 150 days during the year and down the remainder of the time. It was down 12 days to make repairs and the rest of the time on account of high or sufficient stages of water. The maneuvers of the dam and some of the principal items of commerce at No. 4 are given in the following tables:

Maneuvers of dam.	Date.	Time taken.	Men employed.	Remarks.
		h. m.		
Lowered	August 23	3 30	5	No difficulty.
Raised	September 14	8 00	5	Do.
Lowered	November 25	4 00	5	Some trouble with pier tripping bar.
Raised	December 1, 2, and 3	15 00	5	Water rather too high at beginning; some trouble with chains breaking and with drift.
Lowered	December 5	3 00	5	No difficulty.
Raised	December 23 and 24	13 30	5	
Lowered	December 27	2 30	6	Lock bar failed after tripping 10 wickets; rest put down by hand without difficulty.
Raised	May 16 and 17	16 30	6	Found tripping bar off guides; some time spent repairing panels of wickets, etc.
Lowered	May 20	2 30	6	Some of the bar wickets lowered by hand; no particular difficulty.
Raised	June 15, 16, and 17	28 00	6	Found lock tripping bar bent and off guides; also some trouble with drift under wickets.

		Through the lock.	Through the navigation pass.	Total.
Coal	bushels	2,249,000	6,154,000	8,403,000
Coke	tons	1,080	14,940	16,020
Lumber and logs	feet B. M.	307,500	164,000	471,500
Coal barges	number	502	1,138	1,640
Steamboats	do.	784	1,611	2,395
Other craft	do.	29	54	83
Number of lockages	do.			913

Prominent repairs at No. 4.—Owing to trouble with the shortened tripping bar on the lock side, it was still further reduced in length last fall and 12 more of the shunting hurters put in, leaving 14 of the wickets on that section to be operated by the bar. This short bar got off the guides and badly bent again this spring, and had, on the whole, made so much trouble that it was decided to take it entirely out, which was done in June. It will not be put back. The remaining 14 Chanoine hurters on the lock section will be replaced during low water this season with the new pattern. There are still 13 wickets on the pier section operated by the tripping bar.

New top timbers were put on three of the lock gates last winter, the old timbers being badly decayed. These gates are now twelve years old. They are likely, with occasional small repairs, to last several years yet.

Lock No. 5.—Movable dam, finished in 1880. Located 68 miles from mouth of river and 10 miles above Charleston.

The dam was kept up 162 days during the year. The maneuvers of the dam and the most important items of commerce at No. 5 are given in the following tables:

Maneuvers of dam.	Date.	Time taken.	Men employed.	Remarks.
		h. m.		
Lowered	August 23	3 00	5	No difficulty.
Raised	September 4 and 5	11 30	5	Two hours taken in putting tripping bar on track.
Lowered	November 25	3 10	6	No difficulty.
Raised	December 2 and 3	14 30	6	About five hours in righting and adjusting tripping bar. Some delay by chain breaking, etc.
Lowered	December 5	4 00	7	Lowered 11 bar wickets by hand that failed to trip.
Raised	December 23	10 00	7	No difficulty.
Lowered	December 27	3 00	6	Do.
Raised	May 16	12 00	7	Some trouble with drift under wicket chains; 2½ hours in righting bar.
Lowered	May 20	1 30	6	No difficulty.
Raised	June 14 and 15	18 30	5 to 6	6 hours taken on repairs of wickets, etc.

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		Through the lock.	Through the navigation pass.	Total.
Coal	bushels	3,989,500	12,524,500	16,514,000
Coke	tons	1,080	14,940	16,020
Lumber and logs	feet B. M.	1,396,800	914,300	2,311,100
Shingles	number	352,000	.....	352,000
Brick	do	50,500	.....	50,500
Coal barges	do	880	2,134	3,014
Steamboats	do	991	1,580	2,571
Other craft	do	42	75	117
Lockages made	do	.....	.....	1,125

Prominent repairs at No. 5.—The sill of the weir having become so worn and decayed that it would not hold the horse boxes well, it was taken up and a new sill placed this spring before the dam was raised. It may be noticed in this connection that it was on account of this trouble with the timber on the surfaces of the weirs (they being above low water and part of the time exposed) that it has been mostly dispensed with on the weirs in recent construction on the river by fastening the trestle boxes and hurters directly to the masonry and the use of cast-iron sills.

Before raising the dam this spring 28 old weir hurters were taken up and replaced with those of the new shunting pattern. All of the hurters on this weir are now "self-tripping," 26 of the Pasqueau having been placed in 1884.

Lock No. 6.—Movable dam, finished in 1886. Located 54 miles from mouth of river and 4 miles below Charleston.

The dam was up 162 days during the year and down the remainder of the time, owing to high or sufficient stages of water. The maneuvers of the dam and the commerce through and past this lock are given in the following tables:

Maneuvers of dam.	Date.	Time taken.	Men employed.	Remarks.
		h. m.		
Lowered	August 23	2 10	4	No difficulty.
Raised	September 4	6 25	4	Do.
Lowered	November 24	1 30	5	Do.
Raised	December 2	10 00	4	Do.
Lowered	December 5	4 20	4	Delayed two hours by a sunken log under a pass trestle.
Raised	December 24	7 50	4	No difficulty.
Lowered	December 27	1 15	4	Do.
Raised	May 16	10 10	4	Delayed two hours by deposit in pier recess.
Lowered	May 20	1 00	5	No difficulty.
Raised	June 13	8 45	4	Do.

		Through the lock.	Through the pass.	Total.
Coal	bushels	2,438,000	19,393,000	21,831,000
Coke	tons	.....	16,000	16,000
Coal barges	number	792	2,862	3,654
Steamboats	do	763	1,960	2,723
Other craft	do	44	69	113
Miscellaneous freight, merchandise, produce, etc	tons	10,710	36,000	46,710
Passengers	number	8,700	28,300	37,000
Lumber and logs	feet B. M.	1,904,650	7,006,050	8,910,700
Tan bark	cords	88	500	588
Railroad ties	number	7,450	16,700	24,150
Staves	do	.....	300,000	300,000
Brick	do	.....	100,000	100,000
Lockages made	do	.....	.....	951

MISCELLANEOUS WORK.

Dredging, etc.—The Government dredge and towboat were engaged last season in dredging in the pools above Charleston, when not hindered by high water, from July 27 to November 13. They worked in the No. 2 pool at and below Mount Carbon, at Armstrong Ripple, and Wheeler Island from July 27 to August 21; from August 22 to October 12 in the lower approach of Lock No. 2 and at Harvey Shoal, just below No. 2; from October 12 to the 29th at the head of Witcher Creek Shoal. On October

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31 two loaded coke barges got aground just below Lock 2 on some high places missed in the recent dredging, and the boats were taken back and worked there until November 13, when operations were stopped by high water and the dredges laid up for winter.

This spring quite extensive repairs were necessary on the hull of the dredge (now 12 years old) and it was docked and overhauled. Considerable new work was required about the ends, spud-wells, etc. It was also sheathed throughout on the sides above water line with 3-inch white pine and a new deck put down. Some repairs were also made to the machinery and cabin. The towboat was also docked and calked and new hog-chain braces put in, etc.

Since June 21 the dredge has been at work in the No. 4 pool just below Lock 3, where a considerable dredging is required to make depth for full 6½-foot barges in minimum pool stage.

The removing of obstructions from the channel and common coal landings referred to in the last annual report was continued in July, the towboat and crane boat working eleven days that month, taking out 49 snags, logs, etc., between Raymond City and Red House Shoal.

Telephone line.—The Government telephone line now extends from Lock 8 to Kanawha Falls, a distance of 59 miles. In addition to ordinary work required to keep the line and apparatus in order, 83 new poles were put up during the year. The repairs to the line are mostly made by the regular lock hands.

Lock and Dam No. 9.—It being your intention to put the foundations and masonry of Lock and Dam No. 9 under contract as soon as possible after the proposed new appropriation is made, the necessary plans and estimates have been under way and are now nearly completed. Drawings for a single house with an office, needed during construction and finally to be used by the lock-keeper, are also nearly finished.

Survey for No. 10.—A survey and borings for rock for the definite location of Lock and Dam No. 10 were made in May and June, 1892. The map and cross sections are now being platted. The location proposed is just above Intermediate or Lower Debby Ripple, about 19 miles from the mouth of the river. Steps for the procurement of the land needed at the site will be taken as soon as possible after the new appropriation is made.

Two lines of check levels were run last fall between the sites of No. 9 and of No. 10.

Office work and assistants.—In addition to the engineering and drafting work required at the locks and dams under construction, the most important items of office work done during the year, some of which have been referred to above, are as follows: Drawings and specifications for the iron work for the movable parts of Dams 7 and 8, and extra bridge irons for the completed dams; drawings for the foundations and masonry of Lock and Dam No. 9, and for the lock house and office at that site; detailed drawings for publication of Lock and Dam No. 7, in fourteen 25 by 30 inch sheets, with description and profile of river, completed in February and since published by the Chief of Engineers; detailed drawings for publication of Lock and Dam No. 2. The No. 2 drawings will be on 12 sheets of the same size as No. 7 and are now about two-thirds finished.

There has been but little change in the organization during the year, and I take pleasure in acknowledging the faithful and efficient services of the men employed on the work, both on construction and in the office. Mr. Thomas E. Jeffries was engaged during the working season as assistant engineer and inspector on construction of Lock and Dam No. 7, Mr. Theo. Schoonmaker in the same capacity on Lock and Dam No. 8. Both of these gentlemen were employed during the winter and early spring on plans and drawings in this office. Mr. J. R. Myers continued to act as assistant inspector at No. 7, principally on masonry, and Mr. R. M. Stephens in the same capacity at No. 8. Mr. William M. Peyton continued to attend to the accounts and clerical work in this office and to look after the details of the property on the improvement. Mr. C. K. McDermott, civil engineer, was employed on the finished drawings for publication, before described, until February. Mr. A. M. Campbell, civil engineer, has been engaged on these drawings since April.

Very respectfully, your obedient servant,

ADDISON M. SCOTT,
Resident Engineer.

Col. WILLIAM P. CRAIGHILL,
Corps of Engineers, U. S. A.

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UNITED STATES ENGINEER IMPROVEMENT OF THE GREAT KANAWHA RIVER, WEST VIRGINIA—DESCRIPTION, WITH DETAILED DRAWINGS* OF LOCK AND DAM NO. 7.

Brief description of the river.—The Great Kanawha River empties into the Ohio 262 miles below Pittsburg and 205 miles above Cincinnati. It is a continuation of New River, which rises at the base of Grandfather Mountain, between the Blue Ridge and Smoky ranges, in Watauga County, N. C. The length of the New and Great Kanawha together is about 425 miles.

The Great Kanawha is generally spoken of as being formed by the New and Gauley, the latter joining the main stream 2 miles above Kanawha Falls, but the Kanawha is commonly regarded as beginning at the Falls. The distance from the foot of the Falls to the mouth of the river, measuring the surveyed line along the shore, is 95.25 miles.

Slope.—The low-water fall of the river is shown in detail by the profile, Plate 1. The total descent from the foot of Kanawha Falls to the mouth of the river (95¼ miles) is 107 feet. It will be noticed that over 46 feet of this occurs in the first 15 miles. The fall may be divided, using round numbers, as follows, viz: From the foot of the falls to the foot of Loup Creek Shoal, distance 4¾ miles, fall 22 feet; from the foot of Loup to the foot of Paint Creek Shoal (Lock No. 3), distance 10¼ miles fall 24 feet; from the foot of Paint Creek Shoal to Charleston, 21¼ miles, 16 feet; from Charleston to the mouth of the river, 58¼ miles, fall 45 feet. The most of the fall in low stages, as shown by the profile, occurs at the shoals and ripples, the natural pools between them having but little descent. As the river rises the slope becomes of course more uniform, and the effect of the shoals and ripples is reduced and finally obliterated.

Bed, banks, floods, etc.—The bed of the river is composed of bowlders and gravel, with some sand and mud, getting naturally finer towards the mouth. It is underlaid with rock, found at distances varying from about 7 to 18 feet below low-water mark. The depths to rock, as far as ascertained, are shown on the profile. The banks are from 35 to 50 feet high, composed mainly of heavy clay, but with frequent mixtures and strata of sand.

Ordinary Kanawha floods rise about 30 feet in the upper part of the river and 40 feet near the mouth, above low-water mark. The highest recorded rise at Charleston (September, 1861) was 46.87 feet above low water. The extreme high-water line in the lower part of the valley, from about Charleston down, is effected by backwater from the Ohio. The highest water at the mouth and for about 25 miles above, as appears by the profile, was caused by the extraordinary flood in the Ohio of February, 1884. This rose at the mouth of the Great Kanawha and for several miles above, as shown, to about 61 feet above low water.

The average width of the river at low water is about 600 feet.

The "hard pan" overlying the rock at Lock and Dam No. 7 has been found nowhere else in any quantity, and may be considered as peculiar to that site; except as to this, cross-section A B, Plate 2, is a fairly characteristic one of the river, and of the bed and banks in the pools, or between the shoals. The natural low-water depth between the shoals is generally from about 3 to 7 or 8 feet; in many places, as shown by the profile, it is much deeper. On the shoals there was originally but a few inches of water in low stages; scarcely enough on many to float a loaded canoe or skiff. The depths at the shoals and ripples on the profile of the river, Plate 1, are taken in the dredged chutes that have been made for open navigation, as described further on, through all of these obstructions below Loup Creek Shoal. (For fuller description of the natural features of the river and valley reference may be made to the following annual reports of the Chief of Engineers: Report for 1871, page 625; for 1873, page 836; for 1875, Part 2, pages 91 and 95; for 1876, Part 2, page 163; for 1877, pages 307, 320, and 744.)

Discharge—Charleston Gauge.—The discharge of the river for different stages with reference to the Charleston gauge is given below. This gauge was established in June, 1873, at the beginning of work on the river by the United States. It is set to show the available water for open navigation in the Great Kanawha below Charleston. The zero of the gauge is about 1 foot below ordinary low water. The extreme low water of 1881 fell one-tenth of a foot below the zero.

The discharge of the river in cubic feet per second for the different gauge readings is as follows: All of these measurements were made at or near Charleston. All but the first and last were made above the mouth of Elk River; the first was made just below the mouth of Elk, and the last includes the flood discharge of Elk. Gauge one-tenth of a foot below zero (extreme low water), discharge 1,130 cubic feet per second; gauge reading 3.00 feet, discharge 2,942 cubic feet per second; gauge 3.90, discharge 4,925; gauge 5.28, discharge 8,613; gauge 6.80, discharge 12,733; gauge 8.10, discharge 18,562; gauge 9.20, discharge 28,798; gauge 14.40, discharge 47,120; gauge 19.60, discharge 76,851; gauge 32.60, discharge 118,291; gauge 34.60, discharge

* Of these drawings plate I (profile) only is reprinted herewith.

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155,388; gauge 34.60, discharge, including Elk River, 188,347 cubic feet per second. (See Report of Chief of Engineers, 1876, Part 2, page 160; for 1878, page 473, and for 1883, page 714.)

Days per year of different heights.—The average number of days per year the river is at or above certain even stages is as follows, determined by daily records of the Charleston gauge kept at the United States engineer office in that city. The average is for twelve years, ending July 1, 1885, and being before the completion of Lock and Dam No. 6, is for the open river. The gauge was set, as before stated, to show the available depth for open navigation below Charleston. The nearest full day is given for the average in each case, the decimals being omitted:

The river is at or above a 2-foot stage on 337 days per year; at or above a 3-foot stage, 299 days; at or above a 4-foot stage, 250 days; at or above a 6-foot stage, 146 days; at or above a 7-foot stage, 100 days; at or above a 10-foot stage, 35 days; at or above a 20-foot stage, 6 days; at or above a 30-foot stage, 1 day. (Shown in detail on page 1857 of Report of Chief of Engineers for 1885.)

Ice.—The Great Kanawha, as a rule, is but little obstructed by ice. In the last nineteen years navigation has been suspended by it, wholly or in part, an aggregate of one hundred and forty-six days, an average of less than eight days per year. The longest suspension was in the winter of 1876–'77, when navigation was stopped above Charleston by ice gorges thirty-nine days. Aside from an occasional exceptionally cold winter, accompanied with low stages of water, the river seldom freezes over and the moving ice is rarely more than a couple of inches thick. In the winter of 1878–'79 it was covered nearly everywhere, except on shoals, with stout ice from 10 to 12 inches thick. This ice was carried out by a rise from the head waters of New River; it made remarkable gorges in the Kanawha, and did a good deal of damage to steamboats, barges, coal tipples, etc.

IMPROVEMENTS FOR OPEN NAVIGATION.

The shoals were such marked obstructions to an otherwise good river during nearly the whole year for boats of light draft that work on them was begun at an early day. A very interesting account of this early work, navigation, and commerce on the river is given by Dr. J. P. Hale in the History of the Great Kanawha Valley.

The shipment of salt, the first and for a long time the most important article of commerce, was first in canoes and next in flatboats. The beginning with the latter was about 1808, when the first regular salt furnace was built. These flatboats increased in size until they "got up to over 300 tons, carrying 2,000 to 2,200 barrels of salt." These boats were seldom pushed back, but were sold in the Lower Ohio, the early upstream freighting being done in ribbed, keel-bottom boats, called bateaux.

Beginning of work by Virginia.—The following extract by Dr. Hale is from the history referred to: "The first steamboat to attempt the navigation of this river was the *Robert Thompson*, in 1819. She ascended as far as Red House Shoal, but lacking power to stem the swift current at that place, abandoned the effort and returned. In December, 1820, the *Andrew Donnally*, a steamer built for Messrs. Andrew Donnally and Isaac Noyes, salt-makers of this neighborhood, made the first successful run to Charleston, and others soon followed, thus inaugurating the era of steam navigation on the river. Prior to 1820 there had been no formal or organized effort made to improve the navigation of the river, * * * but the failure of the *Thompson* and the success of the *Donnally* was so significant and were considered of so much importance by the legislature of Virginia that at their session in 1820–'21 they passed an order directing the James River and Kanawha Company, in which the State held large stock, to so improve the navigation of the Kanawha River as to secure not less than 3 feet of water for navigation all the year round from the mouth to the falls. Little did they then appreciate the magnitude of the problem they had attempted to solve.

"The execution of this order was delayed, waiting examinations and surveys, until 1825, when a system of chutes and wing dams was commenced and prosecuted for some years. * * * They cut the old chute through the rock at Red House Shoal; the chute at Tyler Shoal; cut the sluices and built the wing dams at Debby, Eighteen, Knob, Tacket, Johnson, etc., so well remembered by the old salt flatboatmen of thirty to fifty years ago."

The shipment of coal for commercial purposes commenced about 1855 and soon reached considerable importance (the salt business had also grown to large proportions), and a better navigation was demanded. On account of this demand the James River and Kanawha Company took more thorough systems of improvement under consideration, and after further surveys (Lorraine-Byers in 1856–'57), and considering different radical plans, mainly that of Fisk by graded sluices, and Ellet's by reservoirs, practically rejected both, and decided to simply better and extend the old plan of improving the shoal by chutes and occasional wing dams.

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The main feature of the new work proposed by the company at this time was the improvement of, and in most cases, the making of new chutes through the shoals by dredging, and a contract was made that embraced a large amount of this work. Four steam dredges, the first on the river, were put to work in the summer of 1860, and this was in progress when suspended in the fall of 1861 by the war.

Work by West Virginia.—After the war the State of West Virginia created the Kanawha River Board to carry on the improvements and collect the tolls, as the James River and Kanawha Company had done before. This board purchased two steam dredges and went on with the work begun in 1860 by the old company, and did a great deal in the way of dredging "dug chutes" through the shoals. These chutes were generally about 100 feet wide, and were used by small coal tows (from two to four barges) in medium or "dug chute" water, and by passenger and light freight steamboats in the same and lower stages.

In a report to Col. Craighill, in 1872 (Report of Chief of Engineers, 1873), Mr. Lorraine describes the condition as follows: "The present improvement, made since Mr. Fisk's report (1855), consists of channels or chutes excavated through the shoals, and occasionally of slight wing dams of stone or gravel, extending from either bank of the river to the chutes, to concentrate the water. This improvement extends as far up as the foot of Loup Creek Shoal. The chutes are from 100 to 120 feet wide, and while they are an improvement on the old chutes * * * and are of some benefit to navigation at certain stages of water, yet at low water they are utterly inefficient, etc. * * * The principal difficulty in the improvement of the river" [*i. e.*, for open navigation], "is the deficiency of water during the dry season."

Referring to the condition of the river about 1871, Dr. Hale (who was for some years a member of the Kanawha Board), in the history of the valley before quoted from, writes: "Notwithstanding the fact that the navigation had been greatly improved within the past few years, it was manifestly inadequate to the wants of the rapidly increasing population and business of the valley. Having admittedly the finest coal field on the continent, it was practically almost valueless for the want of safe, reliable, and economical transportation to markets.

"As there was no local financial ability equal to the task of constructing such an improvement as would fully develop this great interest and effectually serve it and the other growing interests of the valley, it was determined to apply to the General Government for aid in the matter."

By the United States.—The first appropriation by the United States for the improvement of the Great Kanawha was made by Congress in 1872-'73, and was for $25,000. Another appropriation for the same amount was made in June, 1874. Both of these appropriations were expended in improvements for open navigation, mainly in building riprap dams and dikes, removing rocks and snags, and in widening and improving the channels on the shoals for towing by removing dredged walls and cutting down the bars. While this work was in progress the Kanawha River Board continued to act for the State, operating the two dredge boats and collecting tolls. This board was dissolved by act of the legislature in 1883, and the improvement of the river turned over wholly to the United States.

Since the improvement by locks and dams was begun, occasional small sums have been expended on the open improvement in the way of dredging, removing obstructions, and repairing chute walls, as the interests of commerce have required or made advisable.

It may be added in this connection that the work done for open navigation is a necessary part of the permanent improvement by movable dams. The made chutes and towing channels on the shoals must continue to be used in all but high or "bar stages" when the dams are down, and at most of the prominent shoals when the dams are up.

Results accomplished for open navigation.—The result of all the work done on the Great Kanawha for a purely open navigation, and what could practically be attained by such a system has been briefly described above under the heads of "Discharge," "Days per year of different heights," etc., and is more fully set forth in the various reports referred to. It is shown that coal, the important article of commerce, could be shipped from the head of the "Charleston pool" (68 miles from the mouth of the river and now the site of Lock 5), in regular 6-foot draft barges, on an average of about one hundred and forty-five days per year, and that there was a 3-foot depth and upwards, or enough for passenger and light freight packets, to the same point about three hundred days in the year.

This, as shown, was the average for a number of years. It could not, of course, be depended on, for in "low-water seasons" the navigable time, particularly for shipping coal, fell much below the average. For instance, in 1880 there were but ninety-four days, and in 1886 but eighty-two days when 6-foot draft barges could go out from the Charleston pool.

Above the Charleston pool, owing mainly to the heights and grades of the shoals, the difficulties and uncertainties of open navigation increased rapidly as we ascended. Before the completion of the Chesapeake and Ohio Railroad in 1872, steam packets

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ran up to Cannelton, in good stages of water, generally "winding" through the upper shoals. After the railroad was built steamboats seldom went above the foot of Paint Creek Shoal (now the site of Lock 3), and in low or even medium stages there was but little done by river above the Charleston pool.

In reference to coal shipments from the upper river: Locks Nos. 4 and 5, the first built on the river, were completed and put in operation in 1880. At this time there were but two mines above the site of No. 5 shipping by river, and they were doing but little, shipping altogether not to exceed 8,000 tons per year. Several attempts had been made to ship coal from above the foot of Paint Creek Shoal, at Cannelton, Armstrong Creek, etc., but owing to the risks and uncertainties of navigation this had been entirely abandoned before the slack-water improvement began. The immediate practical effect on commerce of the building of locks and dams in this part of the river will be referred to farther on.

IMPROVEMENT BY LOCKS AND DAMS.

The first appropriation for the improvement of the river by locks and dams was made by Congress in March, 1875. Col. (then Major) William P. Craighill, the engineer officer in charge of the river, in a project for the expenditure of this appropriation, dated April 30, 1875 (Report of Chief of Engineers, 1875, page 90), says: "The system of locks and dams may be considered as affording the most reliable navigation at all seasons of the year; and, as the ordinary construction is open to the objection of delaying boats and breaking up tows, the adoption of movable dams seems the best expedient available." * * * "These will furnish an unobstructed navigation during such times as the river will give sufficient depth of water, which will be not less than six months in each year. The system has not been fairly tested in this country, but its long successful use in France would seem to supply the deficiency and justify its adoption under such favorable conditions as are found on the Kanawha."

* * * * * * *

"The profile represents approximately the position and height of the movable dams, the lifts of which vary from 6 to 8 feet up to Paint Creek Shoal. Above that point the fall is greater, and it may be better that the movable dam system be not applied to it, but that the rise be overcome by three locks of 15 feet lift each."

On this project a Board of Engineers, consisting of Lieut. Col. H. G. Wright, and Majs. Craighill and Poe, made a report to the Chief of Engineers, under date of May 25, 1875 (Annual Report for 1875, page 94). The following is an extract from the report of the Board:

"To meet the necessities of such economical transportation a depth of at least 7 feet water should be secured at all times. This, as stated by Major Craighill in his report of April 30 last, may be obtained in three ways: By a system of locks and permanent dams; by a system of locks and movable dams, and by a combination of the two; that is, by locks and movable dams from the mouth of the river to a certain point, with locks and permanent dams above."

* * * * * * *

"They therefore recommend that movable dams be adopted from the mouth of the river to Paint Creek, the first permanent dam being at this point," etc.

This report was approved by the Chief of Engineers and the lock and dam at No. 5 and the lock at No. 4 were put under contract, and the work on them begun in the course of a few months.

The fixed dams, lifts, and number of.—The first project as stated above contemplated three fixed dams of 15 feet lift each above the foot of Paint Creek Shoal carrying the improvement to the foot of Kanawha Falls. It was afterwards deemed advisable to change the plan by reducing the lifts of the fixed dams to 12 feet, and Locks and Dams Nos. 2 and 3 have been so built, the No. 2 pool reaching to the foot of Loup Creek Shoal, as shown on the profile. This is nearly or quite to the upper line of the best coal deposit on the Great Kanawha (being about where the Lower Coal measures run out and the thick top sandstone of the Conglomerate series appears), and it is proposed not to continue the improvement further upstream until the locks and dams are all completed below. The reduction in the lifts will make two more fixed dams necessary if the slack water is carried to the foot of the falls, making four in all instead of three as first proposed. It may be added that the experience at Nos. 2 and 3, particularly in regard to the scour of the banks below the works, has fully justified the change of plan and shown that the height adopted (for maximum 12-foot lifts) is as great as either of these dams should have been built.

Detailed drawings of Lock and Dam No. 2, uniform with those of No. 7 herewith, are now under way for publication by the department.

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The size of the locks.—The first project and estimate was for locks with "clear interior dimensions of about 48 to 50 feet in width and from 285 to 300 feet in length." The locks above Charleston are 50 feet wide in the clear and from 300 to 311 feet long between quoins. Before Lock No. 6 was built, the first below Charleston, it was determined, in order to better accommodate the coal trade, particularly large-sized towboats in the lower river, to build all of the locks below Charleston 55 feet wide in the clear and 342 feet long between quoins. The coal barges are from 24 to 26 feet wide and about 130 feet long. The locks are designed to pass four barges at once or three barges and a towboat.

The building of the locks and dams was begun, as before stated, in 1875. Progress made to date, relative locations, lifts, etc., of each lock and dam are shown on the profile. This, with some other important features and dimensions of each work, is also given in the following table:

No. of lock and dam.	Style of dam.	Maximum lift.	Length of dam.			Lock dimensions.		Location—miles from mouth.	Remarks.
			Navigation pass.	Weir.	Total.	Clear width.	Length between quoins.		
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
2	Fixed	12	.....	.....	524	50	308	85	Finished in 1887.
3	do	12	.....	.....	564	50	311	80	Finished in 1882.
4	Movable	7	248	210	458	50	300	73¾	Finished in 1880.
5	do	7	250	265	515	50	300	67¾	Do.
6	do	8¼	248	310	558	55	342	54¼	Finished in 1886.
7	do	8	248	316	564	55	342	44¼	To be finished in 1892.
8	do	8½	248	292	540	55	342	36	Do.
9	do	6½	248	*300	*548	55	342	25¼	Not begun yet.
10	do	7½	248	*290	*538	55	342	18¾	Do.
11	do	10	248	*420	*668	55	342	1¾	Do.

* Approximate.

Commercial effects of the locks and dams.—The commercial effect of the locks and dams first built on the Great Kanawha, and the additional benefits to result from completing the improvement to the mouth of the river are shown in some detail in the Report of the Chief of Engineers for 1887, page 1921, etc., and by commercial statistics in later Annual Reports, and will be but briefly referred to here.

Dams Nos. 4 and 5 were completed in 1880; No. 3 in 1882; No. 6 in 1886, and No. 2 in 1887. The shipment of coal by river for the year ending June, 1881, was 385,148 tons. It has increased steadily, and in 1891 the river shipment was 1,030,454 tons.

In 1880 there were but two mines above the head of the Charleston pool (the site of Lock 5) shipping by river, and they were sending out altogether not to exceed 8,000 tons per year. There are now 17 mines above No. 5 shipping by river. The output of these 17 mines by river last year was 546,020 tons. It is evident too that the present output of coal from this part of the valley is but a small part of what it will become, as the coal and coke business is being increased and new mines opened all the time.

There are now 21 towboats and about 900 barges engaged in the coal trade on the river.

The ordinary freight and passenger traffic has increased and is still increasing rapidly. In 1886 these boats carried about 41,000 tons of miscellaneous freight—merchandise, farm produce, etc. Last year they carried 64,000 tons. There are now nine packets in the trade, five of them being local boats, the others running from Charleston and above, to Cincinnati, Pittsburg, Gallipolis, or other points on the Ohio.

THE MOVABLE DAMS.

The movable dams are of the Chanoine wicket type, operated from trestle-service bridges. In general features they are all like Dam No. 7, illustrated and described herein. Dams Nos. 4 and 5 were completed and put in operation in 1880, and were the first movable dams in connection with slack-water improvement built in America. Dam 6 was completed in 1886. Nos. 7 and 8 are now building; both are well along and will probably be completed during the present season, 1892.

The operation of these dams on the Great Kanawha, the number of, and time taken in the maneuvers, difficulties met with, number of days the dams are kept up, the cost of operating and maintaining, etc., each year, are fully described in the Annual Reports of the Chief of Engineers.

The experience with movable dams on this river has on the whole been very satisfactory. They are easily and rapidly maneuvered (in these respects Dam No. 6 and

those now under construction have considerable advantage over those first built), the expense of operation and maintenance is but little if any more than with fixed dams, and they prove highly satisfactory to the river interests.

Advantages over fixed dams.—The movable dams are kept up whenever there is not water enough in the river for coal-boat navigation and down at other times. Their advantages over the ordinary fixed dams for a commerce and river like the Great Kanawha are decided, furnishing the benefits of the usual slack water without its most serious drawbacks. With fixed dams everything must pass through the locks; with them navigation is entirely suspended, too, when the river is near or above the top of the lock walls. With movable dams the locks are only used when the discharge of the river is so small as to make them necessary. At all other times they are down, practically on the river bottom, out of the way, affording unobstructed open navigation. This is of great advantage to all classes of commerce, and is particularly so with coal, transported as it is, and empty barges returned, in "fleets" of large barges. More barges can, of course, be taken by a towboat, and much better time made by all kinds of craft in "open river," when there is water enough for such navigation, than when the stage or discharge compels the use of the locks.

The movable dams being down in high water, there is comparatively little difficulty in protecting the banks about the works from scour. In this respect they have considerable advantage, too, over the fixed dams.

Modifications, cost of operating, etc.—Experience with the dams has naturally suggested improvements, and No. 6, the last one completed, has considerable advantages over those first built in strength and durability of construction, facilities for rapid maneuvering, and cost of operation and maintenance. Dams 7 and 8 have been still further improved in some of their details.

No. 6 has been in operation over five years. The average cost of operating and maintaining the lock and dam has been $2,515 per year. This covers wages, supplies, repairs, including considerable addition to the riprapping, and all expenses connected with the work. The entire cost during the five years of repairs on the dam proper and on all of its apparatus, including paints, one of the principal items, has been something less than $250, or an average of $50 per year.

This dam is put up by four or five men in from seven to twelve hours; the usual time is about eight hours. It is lowered with the same force in about two hours. No material difficulty has ever been met with in any of the maneuvers at No. 6.

Four men are employed regularly at each work, the same as at the fixed dams. In raising and lowering the dams one or two extra men are often hired.

Maneuvering the dams.—The operation of raising and lowering the dams is generally understood, or will be inferred from the drawings, but may be briefly described as follows: In raising the pass the bridge is first put up trestle by trestle (they are connected by chains as shown), beginning at the lock. As the trestles come up, and with them the aprons that make the walk, the rails forming the connections and winch track are placed. In raising the trestles the winch (Plate 10) is used by means of the small top crane and sheave. After the bridge is up the wickets are pulled up one by one with the winch and wicket chains until the props drop into the hurter seats. The wickets are not erected or "righted" as fast as pulled up but left "on the swing" (*en bascule*), that is, with the horse erect, the end of the prop in the hurter seat and the wicket in a horizontal position at the top of the horse. In this position the water passes freely under the wicket. If righted as fast as pulled up, the head of water becomes so great that the last wickets can not be safely handled with the winch. After being put on the swing clear across, they are all rapidly righted; this is done with the drum and brake on the winch and wicket chain, the butt of the wicket being held against the pressure of the water and let against the sill without shock. In lowering the pass the wickets are pulled upstream a few inches with the winch by a simple line and grab connection at the top of the wicket. This carries the foot of the prop out of the seat into the descending channel of the hurter, when the grab is disengaged and the wicket falls. After the wickets are lowered the bridge is put down. The maneuvers briefly described above refer particularly to the navigation pass. The weir is maneuvered on the same general plan, but the weir wickets being smaller than those of the pass, they can be raised or lowered, put on the swing, or righted with full head whenever desired. The maneuver of the weir when the dam is up is governed by the stage or discharge of the river, it being kept wholly or partly raised as required to regulate the surface of the pool. A pass wicket, for reasons given above, is never lowered or swung unless the whole dam is to go down.

Telephone line, equipments, etc.—Concert of action is necessary in maneuvering the dams and regulating the pools, and the different works are connected with each other and with the central office at Charleston by telephone. The line is also extended to Kanawha Falls to give notice of floods, and daily communication by mail, and by telegraph when necessary, is had with Hinton at the mouth of the Greenbrier, 60 miles above the Falls.

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A light service boat furnished with a derrick, capstan, and cabin is required at each movable dam to assist in the maneuvers, transport bridge rails, tools, etc. A complete diving outfit is also necessary at each.

On the bank, in addition to the houses for the men, a drum house and tramway to handle apparatus and tools, a carpenter shop, blacksmith shop, and a storehouse are required. Such buildings, except the drum house, are in use at the fixed dams as well. All of the ordinary repairs are made by the regular lock hands.

LOCK AND DAM NO. 7.

Lock and Dam No. 7 is located 14 miles below Charleston and 44¼ miles from the mouth of the river. The building of the lock, or of the cofferdam to inclose it, was begun in April, 1889. The lock was completed, except the gates, in February, 1892. The foundations and masonry for the dam were begun in the spring of 1891, and it is expected the dam will be completed during the present season, 1892.

Foundations.—The foundations are fully shown by the drawings. The bed rock at this site is from 11 feet to 15¾ feet below low-water mark. It is overlaid with "hardpan," a tough, indurated clay, varying in depth from 3½ to 8½ feet. On the hardpan is the river bed of bowlders and coarse gravel mixed with some sand and mud.

The foundations of the lock, except the upper cross sill, all extend to solid rock; those of the dam resting partly on the rock and partly on the hardpan, as shown.

THE LOCK.

The lock is shown on Pls. II, XI, XII, XIII, and XIV. It is 342 feet long, between quoins, with a clear width in chamber of 55 feet. The total length, not including guard cribs, is 411 feet. The walls, including concrete foundations, are from 27 to 31.75 feet high; they are uniformly 20 feet above top of miter sills. The maximum lift, when Dam No. 8 is up and the pools full, will be about 8 feet; with No. 8 down the lift in low water would be about 10 feet.

The cofferdam.—The cofferdam for the lock and guard cribs was 536 feet long up and down stream, with shore ends 152 and 134 feet long. It was built of round timber cribs, sunk in sections to the hardpan, the top bowlders and gravel being dredged off, filled with heavy dredged material, sheathed on the outside and banked with clay and gravel. The cribs forming the sections were 15 feet wide, 21 feet long, and about 19 feet high, the top of the coffer being about 11 feet above low-water mark.

Foundations.—The hardpan was excavated to solid rock and in main part replaced by concrete up to within 5.50 feet of top of miter sills, at which level the masonry of the walls begins. For the purpose of anchorage, part of the masonry under the miter sills extends to the rock as shown (Pl. XI).

Masonry.—The stone used at No. 7 is yellowish and bluish gray, medium and fine-grained sandstone (probably the "Morgantown" and "Mahoning") from three quarries along the river from 1 to 7 miles above the site. It weighs about 150 pounds per cubic foot, and the crushing load of 2-inch cubes varies from 25,000 to 46,000 pounds.

The chamber faces of the walls are of pointed-face ashlar, and the other faces generally, except the back of the land wall, of rock-faced ashlar. The chamber corners, quoins, sills, and coping are dimension stone, bushhammered. The interior of the walls and the back of the land wall and wings were classified as "backing," described in the specifications as follows: "The backing of all the walls shall be of sound, good-sized, vertical-sided stones. It shall generally be shaped up and bedded top and bottom and made to correspond with height of front stone before being brought on the wall. The beds of backing not to exceed 1 inch in thickness. It shall be laid in full beds of mortar so as to thoroughly bond and break joints. The spaces between backing stones, due to irregularities of form, not to exceed 8 inches at the widest point, and are to be filled solid with selected hammer-shaped stones and spalls, carefully laid and settled in mortar." The use of grout was prohibited.

Concrete.—The concrete was mixed in batches of broken stone, 33 cubic feet; sand, 15 cubic feet; cement (Rosendale), 2 barrels. This made 36 cubic feet of concrete rammed in place.

Back of walls, etc.—The back of the land wall was hammer-dressed and laid in offsets. For drainage behind this wall loose stone were placed between the back and embankment leading to a culvert in the lower wing (Pl. XI). Communication between the pools was guarded against by puddle about the upper wing.

Irons in masonry, anchorage, etc.—The miter sills are anchored by 1¼-inch wedge bolts that reach into the bed rock; the sills and anchorage are shown on Pl. XI. The anchorage for the lock gates is shown on Pls. XII and XIII. Line fastenings and ladders are built in the faces of the chamber walls, as indicated on Pl. XI; details of the fastenings are shown on Plate XIV.

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Lock gates.—The gates and gate irons are shown on Pls. XII, XIII, and XIV. The gates are of white oak, built without heel or miter posts, the main beams running through and the ends and center made solid by filling blocks, assembled with horizontal and vertical bolts and keys, and spaces planked as shown. They are suspended at the heel on steel gudgeons and by top fastenings and anchorage, all below the level of the coping. Each leaf weighs complete about 37¼ tons.

The lock is filled and emptied by valves in the gates, each leaf having five cast-iron valves hung horizontally in a wrought frame. The net filling and emptying areas are each close to 68 square feet. The valves are maneuvered by racks and pinions and the gates by spars and capstans, as shown on Pls. XI and XII.

The valve areas are the same as at Lock No. 6, and the chamber contents, owing to the faces of the walls being vertical instead of battered, somewhat less than Lock 6. At No. 6 the lock is filled and emptied at maximum lift in about four minutes. Steamboats without tows are locked either way in from six and one-half to eight minutes.

Quantities and prices.—The lock was built under a contract that covered the lock complete except the gates. It included cofferdamming, pumping, and bailing, and the furnishing of all work and of all materials except the irons, built in the masonry, these irons being supplied by the United States and placed by the contractor. The quantities in the contract and the prices per unit for the work in place were as follows:

Grubbing and clearing complete, $2,000; crib logs in cofferdam, 53,903 linear feet at 28 cents; sheathing for cofferdam, 34,870 feet B. M. at $30; cofferdam filling, 7,361 cubic yards at 60 cents; excavation, common, including dredging, 22,387 cubic yards at 55 cents; hardpan excavation, 3,064 cubic yards at $1.25; rock excavation, 11 cubic yards at $4.80; embankment, 11,031 cubic yards at 50 cents; puddling, 233 cubic yards at $1.50; concrete, 600 cubic yards at $5 and 2,713 yards at $6.25; backing masonry, 5,224 cubic yards at $4.40; rock-face masonry, 2,017 cubic yards at $8.60; pointed-face masonry, 1,836 cubic yards at $9; cut stone (corners, etc., bush hammered), 351 cubic yards at $12; sills, 219 cubic yards at $18; quoins, 76 cubic yards at $25; coping, 377 cubic yards at $25; riprap, hand-placed, 1,987 cubic yards at $3; paving, 1,171 cubic yards at $5; stone filling, 3,165 cubic yards at $1.50; bolt holes drilled in masonry, 1,493 linear feet at 50 cents; timber, white oak, in guard cribs, etc., 60,150 feet B. M. at $40.

The aggregate of the contract was $160,630.24.

THE DAM.

The dam is of the Chanoine wicket type, operated from a trestle service bridge. It is divided in two main parts, the navigation pass and the weir, or in four parts, beginning at the lock, viz, the navigation pass, center pier, weir, and abutment. (See plan of site, etc., Pl. II.)

Navigation pass.—The pass and details of same are fully shown on Pls. II, III, IV, V, VI, and X.

The foundations all rest on concrete, the latter extending to bed rock under the upper and lower or exterior walls, and at wicket and trestle anchorage, and to hardpan elsewhere, as shown. The foundations are 50 feet long up and down stream, between neat lines of walls. The surface or apron of the pass is entirely of masonry except the wicket sill and the timbers for the horse and trestle boxes.

The pass is 248 feet wide. It is closed by 62 wickets spaced 4 feet between centers. The wickets are of oak with pine panels, framed, ironed, and hung, as shown on Pls. IV and V. They are 3 feet 8 inches wide, the space between them being 4 inches, and 14 feet one-eighth inch long. The axis of rotation is 6 feet 10 inches from the butt of the wicket and 5 feet 11 inches vertically above the top of the sill. The top of the wickets stand 13 feet vertically above the sill. The inclination with the vertical is 20° and the lap on the sill is 5 inches. These wickets are a few inches longer than any before built on the river. The details of the wicket and wicket irons and of the horse, prop, and hurter are shown on Pl. V.

The service bridge of the pass is made by 30 wrought-iron trestles, with attached aprons for walk and connecting rails. The trestles are 8 feet apart between centers. The floor of the bridge is 16 feet 9¼ inches above the center of bottom axis of trestles and 2 feet 6 inches above top of wickets or normal pool level. The trestles are connected by chains for use in raising, the aprons forming part of this connection, and have forged stops to fasten the wicket chains in. The details of the pass bridge trestle, apron, rails, and boxes are shown on Pl. VI.

The wickets and bridge are anchored by 1¾-inch rods and cast disks, built in the foundations, spaced 4 feet apart for both wickets and bridge, as shown on Pls. III and IV. The details of the anchor rods and disk are given on Pl. X.

The weir.—The weir is shown on Pls. VII, VIII, IX, and X.

The masonry of the downstream wall of the weir extends to bed rock, the remainder of the foundations resting on the hardpan, as shown generally by cross section

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on Pl. VIII. The space between the upper and lower walls is filled partly with concrete and partly with clay and gravel, the concrete being used about the anchorage and immediately under the surface masonry, as shown.

The weir is 316 feet wide, closed by 79 wickets set 4 feet between centers. The wickets are 3 feet 9 inches wide (the space being 3 inches) and 9 feet 2½ inches long. The axis of rotation measured on the wicket is 4 feet from the butt and vertically 3 feet 4¾ inches from top of sill. The top of the wicket is 8½ feet vertically above the sill. The inclination with the vertical is 20° and lap on sill a fraction less than 4 inches. These weir wickets (those for the weir of Dam 8 now building are the same size) are from 1½ to 3½ feet longer than at the other dams on the river.

The details of the weir wicket and irons, and of the horse and prop, are given on Plate 8. The weir hurter is shown isometrically on Plate 9.

The weir service bridge is made by 39 trestles spaced, except at ends, 8 feet between centers. In general form of construction it is like the pass bridge, the trestles having attached iron aprons, connecting chains, and stops for wicket chains, etc. The details of the trestle, apron, rails, and boxes are shown on Plate 9.

The upper surfaces of the weir foundations of the Great Kanawha dams are all a little above natural low-water mark. On account of this, in recent construction, beginning with Dam 6, the surface is made entirely of masonry (except the upper guard stick and wicket cushions, both easily renewed), and the trestle boxes, wicket sill, and hurters are fastened directly to the coping by wedge bolts, as shown on Plate 8.

The wicket sill is of cast iron, made in sections, with the horse boxes attached—Plate 9. The sill is anchored by rods and disks, as shown on Plates 7 and 8. The details of the anchor rods and disks are given on Plate 10.

Center pier, abutment, etc.—The center pier, the abutment and retaining crib below it, and shore protection, are shown on Plates 2, 3, 4, 7, and 8. The foundations of the pier all rest on bed rock, and are mainly of concrete; about the downstream end the masonry proper extends to rock. The concrete foundations of the abutment extend to rock throughout. The masonry of the pier and abutment is principally rock-faced ashlar with dimension, bush-hammered corners, and coping. The circular recesses in both, for the adjoining trestles of the bridge to fall in, are shown. For drainage back of the abutment, loose stone are placed between the wall and embankment leading to an opening in the lower wing. Puddle is used back from and about the upper wing to prevent communication between the pools.

Quantities and prices.—The foundations and masonry of the dam are being built by a contract that covers the work complete, ready for the wickets and trestles. It embraces cofferdamming, pumping, and bailing, and the furnishing of all work and of all materials, except the iron built into or attached to the work, these irons being furnished by the United States and put in place by the contractor. The approximate quantities and contract prices are as follows:

Grubbing and clearing site complete, $500; cofferdam logs, 80,000 linear feet at 20 cents; sheathing for cofferdam, 53,000 feet B. M. at $30; cofferdam filling, 13,000 cubic yards at 60 cents; excavation common, including dredging, 16,000 cubic yards at 90 cents; hardpan excavation, 1,960 cubic yards at $1.80; rock excavation, 100 cubic yards at $2.50; embankment, 2,000 cubic yards at 60 cents; puddling, 875 cubic yards at $1.50; concrete, 2,830 cubic yards at $7.25; rock-face masonry, 2,270 cubic yards at $10; pointed-face masonry, 450 cubic yards at $13; cut stone (bush-hammered corners, etc.) masonry, 100 cubic yards at $15; sills, 310 cubic yards at $16; coping, 430 cubic yards at $15; stone filling, 938 cubic yards at $1.50; riprap, hand-placed, 700 cubic yards at $2.50; drilling bolt holes in masonry, 5,000 linear feet at 30 cents; timber, white oak, in permanent construction, 110,000 feet B. M. at $50.

The aggregate of the contract, as above, is $118,215.

Total cost of lock and dam.—The estimate for the lock and dam complete is as follows:

The lock, as per details of contract given above	$160,630	
Irons built in masonry of lock	1,093	
Lock gates complete	7,800	
		$169,523
Foundations and masonry of dam, as per details of contract given above	118,215	
Iron work in anchorage and fixed parts of dam	5,500	
Iron work in movable parts of dam	12,700	
Wood work of wickets	2,350	
Diving apparatus and service boats	1,300	
		140,065
Land at site, buildings, engineering, superintendence, and incidentals		34,012
Total		343,600

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In this estimate the cost of unfinished details and work not contracted for is based mainly on the actual cost of same at Lock and Dam No. 6.

ADDISON M. SCOTT,
Resident Engineer.

UNITED STATES ENGINEER OFFICE,
Charleston-Kanawha, W. Va., March, 1892.

COMMERCIAL STATISTICS.

UNITED STATES ENGINEER OFFICE,
Charleston-Kanawha, W. Va., July 23, 1892.

The following statement shows the number of tons of coal, including also that manufactured into coke, mined and shipped from the Great Kanawha Valley, below Kanawha Falls, for the several years named:

Years.	Shipments.			Years.	Shipments.		
	By river.	By railroad.	Total.		By river.	By railroad.	Total.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
1875	161,932	*231,717	393,649	Year ending June 30—			
1876	200,962	*264,386	465,348	1886	714,465	558,150	1,272,615
1877	207,346	*310,352	517,698	1887	929,335	766,436	1,695,771
Year ending June 30—				1888	804,025	838,507	1,642,532
1881	385,148	265,266	650,414	1889	1,076,872	881,245	1,958,117
1883	614,818	531,610	1,146,428	1890	966,462	1,097,337	2,063,799
1884	736,843	482,367	1,219,210	1891	1,030,454	1,146,721	2,177,175
1885	712,493	581,889	1,231,382	1892	1,071,511	1,233,764	2,305,275

* The shipments by railroad for the first three years given, viz: 1875, 1876, and 1877, include the New River mines above Kanawha Falls.

In comparing the shipments by river and railroad the unfinished river improvement should not only be taken into account but also the fact that the railroad shipments include two roads, the Chesapeake and Ohio and the Kanawha and Michigan, carrying to eastern, western, northern, and southern markets.

Tonnage of the Great Kanawha River for the year ending June 30, 1892.

	Tons.		Tons.
Coal 26,787,788 bushels	1,071,511	Shingles, 2,750,000	4,125
Timber, 39,585,000 feet, B. M.	65,975	Brick, 150,000	337
Oak staves, 755,000	2,265	Merchandise and produce by steamboats	74,800
Tan bark, 590 cords	590		
Railroad ties, 924,650	138,697		
Hoop poles, 980,000	2,450	Total tonnage	1,360,750

Total tonnage for 1890 (Report of Chief of Engineers, page 2246) 1,127,232
Total tonnage for 1891 (Report of Chief of Engineers, page 2425) 1,225,355
Total tonnage for 1892 as above 1,360,750

Respectfully submitted,

ADDISON M. SCOTT,
Resident Engineer.

COL. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

F F 2.

OPERATING AND CARE OF LOCKS AND DAMS ON GREAT KANAWHA RIVER, WEST VIRGINIA.

During the fiscal year the expense of operating the locks and dams on the Great Kanawha River, in West Virginia, has been paid in the manner indicated by section 4, act of July 5, 1884.

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In compliance with the proviso to that section, which requires the rendition of an itemized statement of such expenses, I have the honor to forward the inclosed paper:

Statement of expenses during the fiscal year ending June 30, 1892, out of the general appropriation for "Operating and care of canals and other works of navigation," in operating and keeping in repair the locks and dams on the Great Kanawha River, West Virginia.

Lock and Dam No. 2:		
For wages of regular lock hands	$2,204.83	
For repairs and extra labor	1,172.61	
For supplies, as paints, oils, fuel, tools, etc	110.88	
For freights and transportation	4.64	
		$3,492.96
Lock and Dam No. 3:		
For wages of regular lock hands	2,225.06	
For repairs and extra labor	449.40	
For supplies, as paints, oils, fuel, tools, etc	118.60	
For freights and transportation	7.62	
		2,800.68
Lock and Dam No. 4:		
For wages of regular lock hands	2,220.39	
For repairs (including extra bridge irons) and extra labor	623.09	
For supplies, as paints, oils, fuel, tools, etc	141.28	
For freights and transportation	5.96	
		2,990.72
Lock and Dam No. 5:		
For wages of regular lock hands	2,242.66	
For repairs (including extra bridge irons) and extra labor	811.53	
For supplies, as paints, oils, fuel, tools, etc	165.76	
For freights and transportation	6.29	
		3,226.24
Lock and Dam No. 6:		
For wages of regular lock hands	2,278.06	
For repairs (including extra bridge irons) and extra labor	728.09	
For supplies, as paints, oils, fuel, tools, etc	128.42	
For freights and transportation	3.63	
		3,138.20
Superintendence and central office expenses:		
Wages	3,485.31	
Rent and supplies	273.99	
Freights and transportation	9.10	
		3,768.40
Dredging at locks and part of running expenses of steamboat:		
Wages	1,263.40	
Repairs and supplies	829.77	
Freights and transportation	2.75	
		2,095.92
Telephone line:		
For rent of instruments	140.00	
For repairs and supplies	140.38	
For freights and transportation	6.41	
		286.79
Gauge reports:		
For pay of gauge-keepers and reporters at Hinton and Kanawha Falls	145.50	
For repairs and supplies	4.96	
		150.46
Miscellaneous:		
Repairs to flatboats in general work	53.59	
		53.59
Total		22,003.96

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F F 3.

IMPROVEMENT OF ELK RIVER, WEST VIRGINIA.

Between July 1 and 11 a small party continued the work in progress June 30, 1891, at and near Jarretts and Porter shoals, which are, respectively, 12 and 7 miles from the mouth of the river. Twenty-three snags and sunken trees were taken out and cut up, and a number of leaning trees cut down or the projecting limbs removed. A towpath was also made high up along the bluff at Porter Shoal, and two ring-boats were put in for use in winding boats through the shoal.

Some other work was done in July, August, and September below Clay Court-House, at Yankee Dam, Big Laurel, Big King, Little Spread, Queen, and Porter shoals, in building, repairing, and modifying chute walls and dikes and removing rocks.

In the stretch between the 34 and 38 miles above Sutton, which is itself 100 miles from the mouth of the river, a number of shoals were worked over which had been left in November, 1888. The principal operation was the removal by blasting of about 4,500 cubic yards of large rock to facilitate the movement of much lumber to market in the shape of loose logs. Above Sutton there is no boating or rafting of any consequence, but below there is a considerable movement of rafts and separate logs of valuable timber, railroad ties, and sawed lumber in rafts, all downstream, and of push-boats with merchandise upstream.

The operations of the United States on the river have greatly improved it for the kind of navigation on it. There are still several mill dams which are unreasonable obstructions to navigation. They have been reported as such to the proper authorities in compliance with the law.

The following are the amounts and dates of apropriations for improving Elk River, West Virginia:

June 18, 1878	$5,000	August 11, 1888	$3,000
June 14, 1880	5,000	September 19, 1890	2,500
March 3, 1881	5,000		
August 2, 1882	2,000	Total	24,000
August 5, 1886	1,500		

Money statement.

July 1, 1891, balance unexpended	$2,754.31
June 30, 1892, amount expended during fiscal year	2,595.42
July 1, 1892, balance unexpended	158.89
Amount appropriated by act approved July 13, 1892	2,500.00
Amount available for fiscal year ending June 30, 1893	2,658.89
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	5,000.00

REPORT OF MR. ADDISON M. SCOTT, RESIDENT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston-Kanawha, W. Va., December 16, 1891.

COLONEL: I have the honor to submit the following report of operations since July 1 on the improvement of Elk River, West Virginia.

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The work was stopped October 21 for want of funds, the appropriation being practically exhausted.

With the exception of a few days' work early in July, near the mouth of the river, at removing snags, etc. (in continuation of that reported for the year ending July 1, 1891), work was directed to blasting a channel for logs through the large loose rock on the shoals in the upper river near Webster, Court-House, and in building, repairing, and altering chute walls and dikes and removing rock between Clay Court-House and the mouth of the river.

REMOVING ROCK IN THE UPPER RIVER.

This work was begun September 1 with a hired force under Mr. W. A. Porter, overseer, 5 miles below Addison (Webster Court-House), where it was left November 24, 1888. (Report of Chief of Engineers for 1889, page 1956, etc.) The weather and stage of water were favorable and the work went on without interruption until stopped, October 21, as stated above. This, with the exception of some work at Mill Run and Canoe Tree Shoals, left unfinished, owing to high stages of water in 1888, brought the work up to Addison, being all that was contemplated this season in this part of the river with the funds at hand.

The names and location of the shoals and the principal data connected with the work at each are given in the following table.

The distances are given from Sutton (Braxton Court-House) as in former table. Sutton is 100 miles from the mouth of the river:

Name of shoal.	Miles above Sutton.	Rocks blasted.	Holes drilled and blasts fired.	Rocks blasted and disposed of (approximate).
				Cubic yds.
Painter Lick Shoal	34	50	74	234
Miller Shoal	34½	59	144	1,129
Skidmore Shoal	34¾	17	31	272
Chrisaline Shoal	35	23	35	241
Big Island Shoal	35½	38	97	974
Cat Hole Shoal	35¾	18	20	151
Farley Shoal	36	53	66	739
Upper Cat Hole Shoal	36½	43	57	444
Phares Shoal	37	2	9	67
Fall Hole Shoal	37½	15	34	148
Shoal just below Addison	38	2	13	19
Total		320	580	4,418

There is a large quantity of fine timber on the Upper Elk, and all of the work done by the Government on this part of the stream has been to assist in driving and floating loose logs. Owing to the character of the stream above Sutton no rafting or push-boating is done above that point.

As in 1888, and described in the report referred to, the work in this part of the river consisted in blasting away the worst rocks on the shoals to make a narrow channel, generally about 25 feet wide, for logs to run in.

On most of the shoals worked on the passage could be made wider to advantage by more blasting, and in several places short dikes and dams would be useful in keeping logs out of bad lodging-places in pockets and behind islands.

WORK BELOW CLAY COURT-HOUSE.

This work was done by hired labor in July, August, and September. Mr. Leslie Frame, a pilot and lumberman of Braxton County, was the overseer on the most of this work. It consisted principally, as stated above, in building, repairing, and changing chute walls and dikes and removing rock on the most troublesome shoals. The names and location of the shoals and a brief description of what was done at each here follows:

Yankee Dam Shoal (46 miles from mouth of river and 7 miles below Clay Court-House).—Three riprap dikes were built, two at the head and one near the foot of the shoal, to concentrate and direct the water in log and rafting stages. In addition, a small bar or tow-head and a piece of an old dike were taken out on the right, near the head of the shoal, the bar being reduced by horse scrapers.

About 554 cubic yards of stone were used in building the dikes, all of which were picked up on the shoal, and mostly out of the rafting channel. Material moved from tow-head and old dike, about 210 yards.

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Big Laurel Shoal (37 miles from mouth of river).—Built a timber and stone dam at head of shoal out from left shore, past head of island, 594 feet long, 7 feet wide on bottom, and about 3 feet high. Also repaired and strengthened an old dike on the right shore; 1,170 linear feet of round timber and about 415 cubic yards of new stone were used in the dam and dike.

Big King Shoal (31 miles from mouth of river).—Built a timber and stone dam at head of shoal 255 feet long, 9 feet wide at base and 6 feet at top, and 5 feet high, from right bank to island. Material used in dam, 2,950 linear feet of round timber and about 255 cubic yards of stone.

Also moved an old riprap wall on left of channel and rebuilt it, lengthening both ends, near left shore. This wall, as first located, proved to be a good deal in the way of rafts and boats at certain stages of wacer, and was changed at the request of several of the best pilots. About 365 cubic yards of stone were handled in moving and lengthening the wall.

Little Spread Shoal (27 miles from mouth of river).—Built a timber and stone dike out from the left shore to hold up the water on the shoal and keep rafts from running into the bank. The dike is 440 feet long, 8 feet wide at base, 6 feet at top, and 4 feet high. In building it 3,555 linear feet of round timber and 327 cubic yards of stone were used.

Queen Shoal (25 miles from mouth of river).—Moved farther to left and rebuilt a part of the old riprap wall on left to improve the channel for rafts and boats; moved and placed about 550 cubic yards of stone.

Porter Shoal (7 miles from mouth of river).—The work done here consisted in blasting or breaking up with sledge sand removing a number of large rocks from along the left bank that were quite an obstruction to rafts and steamboats, particularly, the latter, in high stages of water. The rock disposed of aggregated about 140 cubic yards.

REMOVING SNAGS, ETC.

The small party engaged in May and June in removing obstructions below Queen Shoal, in the interest mainly of steamboat navigation, as described in the last Annual Report, continued operations until July 11, when it was disbanded. The work done by this party in July was at and near Jarretts and Porter shoals. Twenty-three snags and sunken trees were taken out and cut up and a number of leaning trees cut down or the projecting limbs removed. In addition, a "towpath" was made high up along the bluff bank at Porter and two ringbolts put in for use in winding boats through the shoal.

Very respectfully, your obedient servant,

ADDISON M. SCOTT,
Resident Engineer.

Col. WILLIAM P. CRAIGHILL,
Corps of Engineers.

COMMERCIAL STATISTICS.

UNITED STATES ENGINEER OFFICE.
Charleston-Kanawha, W. Va., July 18, 1892.

Commercial statistics for Elk River, West Virginia.

Year ending June—	Saw logs and lumber.	Railroad ties, oak.	Oak staves.	Hoop poles.	Hickory spokes.	Oak tan-bark.	Tonnage of timber products.
	Feet, B. M.					*Cords.*	*Tons.*
1883	5,200,000	100,000	898,334	.....	.....	.....	24,790
1884	5,975,000	125,000	1,122,500	.....	.....	.....	30,700
1885	5,100,000	250,000	1,433,750	.....	.....	.....	33,500
1886	15,361,000	250,000	1,845,000	.....	.....	.....	68,510
1888	15,900,000	330,000	1,210,000	.....	.....	.....	71,150
1889	15,750,000	295,000	1,600,000	500,000	350,000	.....	70,200
1890	26,650,000	330,000	1,380,000	150,000	568,000	300	89,880
1891	27,995,000	412,500	800,000	125,000	2[illegible]0,000	500	103,700
1892	44,400,000	380,000	1,405,000	.....	.....	240	139,800

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The marked increase in the output of lumber will be noticed. The 44,400,000 feet of lumber is divided in kind about as follows: Poplar, 33,000,000; white oak, 8,000,000; hemlock, 1,500,000; the rest being mainly walnut and ash.

The amount of general merchandise and produce carried on the river is estimated at 10,000 tons, making the total for the year, with the timber products as above, 149,800 tons.

F F 4.

IMPROVEMENT OF GAULEY RIVER, WEST VIRGINIA.

The small amount of money available for this river was expended in July, August, and September, 1891. The unfinished channels made in 1890 through the shoals within 7 miles of Gauley Bridge were cleared of rocks and some new training walls were built for them. The channel for boats, 30 feet wide and 2 feet deep at low water, was completed to the foot of the Little Roughs, 12¼ miles.

A channel 30 feet wide was also made through the Little Roughs by blasting out large bowlders, the object being to facilitate the downward movement of logs.

The formidable obstruction known as the Big Roughs was also attacked by blasting the large bowlders which form it.

The total number of cubic yards of rock removed was 3,184, and 6,980 linear feet of walls were built.

The work of the year has had the effect of causing the movement of much local freight by boats which would otherwise have been hauled by teams at greater cost to the community.

The following letter explains itself:

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., May 31, 1892.

GENERAL: In the money statement in the last annual report, under the head of Gauley River, West Virginia, the following is found: "Amount (estimated) required for completion of existing project, $4,000."

The project under which Congress has given two appropriations contained two heads, viz, the improvement from the mouth of the river to the Roughs for bateaux navigation, $10,000, and for the improvement of the Roughs, and above, $65,000; total, $75,000. See Annual Report for 1888, Part 3, page 1762. The appropriations up to this time have been, August 11, 1888, and September 19, 1890, each $3,000, amounting to $6,000.

Work was first begun on the portion below the Roughs, of which the cost was estimated to be $10,000, and when $4,000 was stated a year ago to be the balance estimated for completion of existing project it was understood to refer to that portion of the river. The statement should have read "Amount (estimated) required for completion of existing project below the Roughs, $4,000," and that it did not so read was my fault.

In preparing the Annual Report for the current fiscal year doubt now arises as to what amount should be stated as that "required for completion of existing project."

The original estimate was $75,000 for the two items as explained above, and I request authority to use this total in the money statement after deducting appropriations made prior to June 30, 1892.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The following are the amounts and dates of appropriations for improving Gauley River, West Virginia:

August 11, 1888	$3,000.00
September 19, 1890	3,000.00
Total	6,000.00

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Money statement.

July 1, 1891, balance unexpended	$2,938.96
July 30, 1892, amount expended during fiscal year	2,856.28
July 1, 1892, balance unexpended	82.68
Amount appropriated by act approved July 13, 1892	3,000.00
Amount available for fiscal year ending June 30, 1893	3,082.68
Amount (estimated) required for completion of existing project	66,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. WILLIAM PROCTOR SMITH, ASSISTANT ENGINEER.

BALTIMORE, MD., *November 16, 1891.*

COLONEL: I have the honor to report the following operations on the improvement of Gauley River, West Virginia, for the season of 1891.

The river being very low in May it was thought advisable to start the work, and accordingly everything was made ready by the 1st of June, when rains set in which kept the river up until the 29th, at which time work was begun and continued until the 22d of September.

It was found that the channels made in 1890 needed clearing out and that additional wing walls were desirable; so work was begun on them, beginning at the Big Creek, 1¾ miles above the mouth of the river, and extended to and through Mill Shoal, 7¾ miles above the same point, from which were removed 712 cubic yards of loose sand and 12 cubic yards of solid rock, and 1,004 linear feet of main and wing walls were built.

Owing to the large amount of work absolutely required in this part of the river, the project for the season could not be carried out in full.

The new work began at Humphreys Shoal, 1½ miles above the mouth of the Gauley, and channels were made through the shoals left last season, as far as the head of Mill Shoal, 7¾ miles above the initial point; from which place to Sugar Creek, 6¾ miles further up the river, the work was entirely new during the season.

The combined width of the shoals in the whole distance of the new work amounts to 8,623 feet, covering a river space of 7½ miles, from which were removed 857 cubic yards of loose and 1,603 cubic yards of solid rock, with which were built 5,976 linear feet of main and wing walls.

The wing walls were built of loose stone, borrowed from points near by, mixed with brush and gravel and sand when the latter could be procured.

The total amount of loose rock for the season was 1,569 cubic yards; of solid rock, 1,615 cubic yards; in all, 3,184 cubic yards.

The walls vary in width from 3 feet to 10 feet, and in height from 1 foot to 5 feet, and amount to 6,980 feet in length.

The combined widths of shoals amount to 14,137 feet, or nearly 2¾ miles.

The total fall over the shoals and ledges from the mouth of the river to the head of the Big Roughs, 13.4 miles, is 79.8 feet, and the entire fall of the river between these points can be but little more, although the levels were not taken.

At Tritts Shoal, 9¾ miles above the mouth of the river, two channels were made, one long and curved for extreme low water, the other short and straight for water at and above zero.

The bateau channel, 30 feet wide and 2 feet deep at zero or ordinary low water, was completed to the foot of the Little Roughs, 12¼ miles, on the 8th of August, and there the force was reorganized, put in camp, and set at work at that point, Little Roughs, by blasting out the large bowlders for floating logs, through which was made a channel 600 feet long and 30 feet wide, requiring the removal of 30 rocks, containing 310 cubic yards. The Little Roughs, as shown on the tracing of map accompanying this report, is the beginning of the "Roughs" of Gauley, which extend from this point up the river for a distance of 26 miles, as mentioned in your report December 26, 1887, page 1761, Appendix D D 6 of the Annual Report of the Chief of Engineers, U. S. Army, for 1888, and the shoal called Big Roughs, on the same map, is the fourth in this series.

This completed, the force was moved to Big Roughs, 1 mile up the river, a partial channel having to be made through Beaver Pond Shoal and Camp Shoal to admit the passage of the boats.

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Through the Big Roughs a channel 30 feet wide and 900 feet long was made on the right bank, and from the left bank, near the head of the shoal, another channel of the same width was made intersecting the former 479 feet below, in all, 1,379 feet, from which were blasted 31 rocks, containing 1,249 cubic yards.

In these Roughs at the rapid portions there are no fragments over 6 inches above zero, and in the still water below none over 1 foot above the same plane; thus with a 2½-foot, or 3-foot rise logs can be floated without obstruction.

The bateau channel is 12¼ miles in length, and the logging chute 1½ miles.

Eleven distinct rises occurred, varying in height from three-fourths of a foot to 7½ feet.

The highest gauge reading was 6.5 feet above and the lowest 1.9 feet below zero or ordinary low water. Out of seventy-seven working days seventeen were lost. The average number of men employed was 14.1 per day. Rain fell on twenty-six days during the working period. Four hundred pounds of Hercules dynamite and 1,600 feet of double-taped fuse were used.

The loose rock was removed at a cost of 62½ cents per cubic yard and the solid rock, or rather bowlders, for 80 cents per cubic yard. One bateau and one rock boat was hired during the season. There are four bateaux and three flat boats in use on the river.

There are five saw and two stave mills in operation in this section and another of the latter is being put in place. Three million six hundred and thirty-five thousand feet of lumber, 600,000 staves, and 500,000 feet of logs are now in the river ready for shipment. The above will be shipped as soon as a new incline is made at Gauley Station, Chesapeake and Ohio Railway, the facilities for handling lumber at the station being utterly inadequate.

Out of 31 shoals from the mouth of the river to Sugar Creek, 14 miles, 28 were worked at during the season. The work whilst making the bateau channel was done in unfavorable weather. Frequent rains caused high and swift water, which made the work more expensive and less satisfactory in every way.

The work at Big and Little Roughs was done under more favorable circumstances, and had not the appropriation given out operations could have continued throughout September and the first week in October, for there were no rains and the river fell to 2.25 feet below zero, stopping navigation and leaving only about 6 inches in some of the channels and in others scarcely any.

Since the improvement began in the fall of 1888 there has been no ice, consequently it remains to be seen what effect it will have on the walls, which in the greater part are made of small loose stone and liable to be worn down. At the same time it will be interesting to observe the effect of the ice on the loose material in the logging "chutes."

In view of putting on a small stern-wheel tugboat, which is contemplated by some of the boatmen, it is respectfully recommended, in order to straighten the channels, that a "chute" be made through Scrabble Creek Ledges near the left bank of the river with wing walls, to cost $110, and that the channel be widened 10 feet at Buck Ford Ledges, to cost $75, these ledges being respectively one-fourth and two-thirds of a mile from the mouth of the river. Also, work straightening channel at the head of Big Creek, to cost $40, and channel near the left bank of the river, at Winding Shoal, to cost $85, the former 1¾ miles and the latter 2⅛ miles above the mouth of the river.

Whether the boat be built or not, it is recommended that a straight channel be made at Mill Shoal, 7¾ miles above the initial point, 800 feet long and 30 feet wide, near the right bank of the stream, to cost, as near as can be estimated, $900. The old channel here is curved, and the grade occurs at the curve, making it difficult to navigate when the water is comparatively high.

At Tritts Shoal, 9¾ miles above the mouth of the river, the short channel should be deepened and wing walls be built to throw all of the water into it, at a cost of $90.

At Big and Little Roughs some bowlders should be blasted out at the middle and lower ends of the channel, at a cost of $100.

Total estimated amount recommended for improvement of present channels, $1,400.

Reference is made to a table for details of the work at the various points and to another table for commercial statistics.

Sketches of the river, at the points worked at, were made and placed at their respective estimated positions on a map to the scale of 800 feet to the inch, made after the fieldwork was completed.

The map shows all of the shoals, ledges, and roughs on the Gauley as far as the improvement has gone and the manner in which they were improved.

A tracing of the map accompanies this report.

Respectfully submitted.

WM. PROCTOR SMITH,
Assistant Engineer.

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Col. WILLIAM P. CRAIGHILL,
Engineer Corps, U. S. A.

Table showing the distances from Gauley Bridge, W. Va., to foot of shoal or ledge, their length, and difference of level between head and foot of same; also the quantity and quality of material excavated in making and improving the channel in Gauley River, West Virginia, from its mouth to Sugar Creek, in Fayette County, W. Va., 1891.

Name of shoal.	Number.	Distance.	Length.	Fall.	Loose rock.	Solid rock.	Total.	Blasts.	Holes.	Walls.	Bowlders.	Drilling.
		Miles.	*Feet.*	*Feet.*	*Cu. yds.*	*C. yds.*	*C. yds.*	*No.*	*No.*	*Feet.*	*No.*	*Feet.*
Junction of New and Gauley Rivers	1	.....	200	.....	.....	.....	.....	.....	.....	.....	.....	.....
Scrabble Creek ledges	2	¼	330	.8	.....	.....	.....	.....	.....	.....	.....	.....
Buck Ford Ledges	3	⅜	339	1.2	.....	.....	.....	.....	.....	.....	.....	.....
Humphreys Shoal	4	1½	100	.4	24	.....	24	.....	.....	50	.....	.....
Big Creek Shoal	5	1¾	846	3.2	12	.....	12	.....	.....	.....	.....	.....
Poal Shoal	6	2	283	.1	10	.....	10	.....	.....	.....	.....	.....
Winding Shoal	7	2¼	400	1	15	.....	15	.....	.....	30	.....	.....
Kincaid Shoal	8	2½	525	1.6	75	.....	75	.....	.....	.....	.....	.....
Durden Shoal	9	2⅝	460	1.9	108	4	112	3	3	168	.....	4
Durden Ripple	10	3	168	.2	2	.....	2	.....	.....	.....	.....	.....
Long Shoal	11	3½	976	2.8	105	1	106	.....	.....	246	.....	.....
Twenty-mile Creek Shoal	12	5	1,464	4.1	90	2	92	1	1	96	.....	2
No. 1, above	13	5¾	205	1.2	118	.....	118	6	6	196	.....	5
No. 2, above	14	6¼	143	.2	20	.....	20	.....	.....	84	.....	.....
No. 3, above	15	6⅜	100	.3	18	.....	18	.....	.....	130	.....	.....
Foster Shoal	16	6¾	482	2.3	83	6	89	4	4	894	.....	8
No. 1, above	17	7	42	.6	8	.....	8	.....	.....	84	.....	.....
No. 2, above	18	7¼	37	.2	6	.....	6	.....	.....	37	.....	.....
No. 3, above	19	7 7/16	265	.9	69	.....	69	.....	.....	265	.....	.....
Mill Shoal	20	7½	1,075	6.5	135	5	140	3	3	54	.....	5
Church Hollow Shoal	21	9¼	580	2.5	43	.....	43	.....	.....	579	.....	.....
Simms Shoal	22	9⅜	178	1.1	18	2	20	1	1	178	.....	2
Tritts Shoal	23	9¾	745	3.6	218	12	230	10	10	1,400	.....	9
Ford Shoal	24	10	200	2	9	.....	9	.....	.....	200	.....	.....
Laurel Shoal	25	10½	200	2.5	112	.....	112	.....	.....	253	.....	.....
Upper Shoal	26	10¾	690	4.1	124	.....	124	.....	.....	1,388	.....	.....
Little Ledges	27	12⅛	204	1.1	123	24	147	21	21	348	10	24
Little Roughs	28	12¼	600	9.1	.....	310	310	70	66	.....	30	138
Beaver Pond Shoal	29	12⅝	900	8.7	17	.....	17	.....	.....	200	.....	.....
Camp Shoal	30	12¾	500	.8	7	.....	7	.....	.....	100	.....	.....
Big Roughs	31	13¼	900	14.8	.....	1,249	1,249	152	150	.....	31	406
Total	.....	.....	14,137	79.8	1,569	1,615	3,184	271	265	6,980	71	603

COMMERCIAL STATISTICS FOR GAULEY RIVER, WEST VIRGINIA.

Year ending June 30—	Saw logs.	Lumber.	Staves.	Tonnage of timber.	Produce, etc.	Total from Gauley.	Merchandise to Gauley.
	Feet.	*Feet.*			*Tons.*	*Tons.*	*Tons.*
1888	691,800	2,535,300	177,400	7,121	36	7,151	750
1889	890,400	3,615,000	274,200	9,491	78	9,569	1,322
1890	384,800	4,452,500	.....	9,676	90	9,766	1,985
1891	384,700	4,701,300	100,000	10,347	89	10,436	1,964

This commerce is carried on with four bateaux and four flatboats, drawing about 18 inches of water and of 18 tons capacity each.

Commercial statistics for Gauley River, West Virginia, from July 1, 1891, to June 1, 1892—eleventh months.

Lumber	feet	5,249,200
Saw logs	do	261,170
Staves	number	1,200,000
Shingles	do	111,000
Total timber in	tons	9,527
Produce, etc	do	103
Total from Gauley	do	9,630
Total to Gauley	do	3,083

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F F 5.

IMPROVEMENT OF NEW RIVER, VIRGINIA AND WEST VIRGINIA.

There has been no work on this river in the year ending June 30, 1892.

The following are the amounts and dates of appropriations for improving New River, Virginia and West Virginia:

August 14, 1876	$15,000	August 2, 1882	$12,000
June 18, 1878	15,000	August 5, 1886	10,000
March 3, 1879	12,000		
June 14, 1880	24,000	Total	112,000
March 3, 1881	24,000		

Money statement.

July 1, 1891, balance unexpended	$2,341.79
July 1, 1892, balance unexpended	2,341.79
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	159,000.00

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APPENDIX G G.

IMPROVEMENT OF CERTAIN RIVERS IN KENTUCKY AND WEST VIRGINIA.

REPORT OF MAJOR D. W. LOCKWOOD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Tradewater River, Kentucky.
2. Operating and keeping in repair locks and dams on Green and Barren rivers, Kentucky.
3. Rough River, Kentucky.
4. Kentucky River, Kentucky.
5. Operating and keeping in repair locks and dams on Kentucky River, Kentucky.
6. Licking River, Kentucky, between Farmers and West Liberty.
7. Big Sandy River, West Virginia and Kentucky.
8. Levisa Fork of Big Sandy River, Kentucky.
9. Tug Fork of Big Sandy River, West Virginia and Kentucky.
10. Guyandotte River, West Virginia.
11. Little Kanawha River, West Virginia.
12. Operating and keeping in repair the lock and dam on Little Kanawha River, West Virginia.
13. Buckhannon River, West Virginia.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 8, 1892.

GENERAL: I have the honor to transmit herewith, in duplicate, the annual reports on the works under my charge at the close of the fiscal year ending June 30, 1892.

First Lieut. William L. Sibert, Corps of Engineers, has been on duty under the direction of this office throughout the year.

Very respectfully, your obedient servant,

D. W. LOCKWOOD,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

G G 1.

IMPROVEMENT OF TRADEWATER RIVER, KENTUCKY.

The Tradewater is a tributary of the Ohio and empties into it 79 miles below Evansville, Ind.

The project for the improvement, adopted in 1881, contemplated originally the removal of obstructions, such as bars, snags, etc., so as to

open up to navigation 22 miles of the river by forming a channel with a minimum width of 40 feet and a minimum depth of 2½ feet for 6 months. The survey upon which the project was based covered 41 miles of river, and the scope of the work has been extended to embrace this, although the depth of water, 2½ feet, can only be secured for about 5 months each year in the upper portion.

The last work done on this river closed December 23, 1890. It had then been thoroughly gone over from its mouth to the upper limit of the improvement, 41½ miles above.

The small balance is held to be used in taking out snags and logs that are constantly coming into the channel during each high water.

APPROPRIATIONS.

March 3, 1881	$3,000
August 2, 1882	3,500
July 5, 1884	2,000
August 5, 1886	2,000
August 11, 1888	6,000
Total	16,500

Money statement.

July 1, 1891, balance unexpended	$1,018.54
June 30, 1892, amount expended during fiscal year	111.44
July 1, 1892, balance unexpended	907.10

G G 2.

OPERATING AND KEEPING IN REPAIR LOCKS AND DAMS ON GREEN AND BARREN RIVERS, KENTUCKY.

The United States acquired possession of these locks and dams December 11, 1888, by purchase. At that date four of the locks, to wit, Nos. 1, 2, and 4, Green River, and No. 1, Barren River, were being operated. The river wall of No. 3, Green River, was down, having fallen into the river about the first of the year. No. 2, Green River, was and had been for years in a dilapidated condition, the river wall having yielded outward, and the land wall was only kept from falling into the lock chamber by being anchored to cribs in rear of it filled with stone.

At No. 1, Barren, the lower end of the land wall had cracked badly and was in danger of falling at any time. The first work evidently was that of restoring navigation by the reconstruction of the river wall at Lock No. 3, and as the lower end of the land wall of No. 1, Barren, was apparently unsafe, it was deemed best to rebuild it at the same time. The above was done in time to reopen the river to navigation on November 10, 1890.

During the past fiscal year navigation has been continuous except for a few days, when No. 1, Green, was shut down to repair the lower miter sill, and when it was found necessary to do the same at No. 3.

The dams, at the time the United States acquired control of them, were, in some cases, in bad condition. This was especially the case at No. 1, Barren, and at No. 2, Green.

These dams have been rebuilt from the crest forward, and are now in thorough repair. At No. 2, Green, the dam now extends straight

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across the river from the lock, the old forebay section for the sawmill on the abutment side having been taken down, and the rock ledge upon which it rested blasted out so that part of the lower slope of the dam next the abutment is now rock. This has increased the available spill of the dam somewhat and diminished the force and extent of the eddy near the lower entrance of the lock. The upper entrance of this lock has been greatly improved by dredging off the point of land at the upper end.

The old abutment at No. 4 is in a dilapidated condition and should be rebuilt. There has been trouble for years at the abutment end of this dam, and a deep hole above and below the dam indicate the presence of an extensive leak. The hole above has been in times past filled with stone, and last year a large crib filled with stone was placed in the hole below the dam. This answered very well, except that the top sheeting was torn off, due to the fact that it was placed close together, so that the water leaking through the dam could not escape.

At Dam No. 1 there has always been trouble from backwater, which has washed the backing of the upper breast away almost every winter; one year the lower slope was turned over upstream by the back current from the Ohio. This dam is hard to keep tight any way, as the upper breast slope is longer than the lower slope. About the best way of stopping leaks through it found so far is to throw into the river just above the dam hickory lathe saw-dust when the water is low below.

A part of the lower slope of this dam was carried away during the past winter, but just how extensive the damage is can not be determined at present, as the water is too high to make a proper examination.

There is but little change noticeable in the condition of Lock No. 2. The leakage through the river wall, etc., is so great that, with the filling valves open, the upper gates have to be opened against a head of 6 inches. A new lock seems absolutely necessary here, and it should be provided for within a short time. By making the pool depth on lower miter sill 6 feet and raising the dam 8 inches there will be 6 feet navigation in Green River above No. 1. This I regard as a matter of great importance, as it will give increased facilities for boating coal by affording 6 feet navigation whenever there is sufficient water in the Ohio.

For details of work done during the past year attention is invited to the report of Lieut. William L. Sibert, Corps of Engineers, attached hereto.

APPROPRIATIONS.

August 11, 1888, for purchase	$135,000.00

ALLOTMENTS.

January 4, 1889	167,112.00
July 20, 1889	139,110.00
July 17, 1890	53,783.47
July 16, 1892	77,807.26
Total	437,812.73

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Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Green and Barren rivers, Kentucky, improved by locks and dams, during the fiscal year ending June 30, 1892.

LOCK No. 1, GREEN RIVER.

Months.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.				
July	$187.40	$59.47	$45.08	$291.95
August	395.00	.....	24.73	419.73
September	95.00	683.61	150.77	929.38
October	95.00	296.06	57.13	448.19
November	152.40	420.50	17.72	590.62
December	585.40	95.11	52.16	732.67
1892.				
January	288.60	1.50	15.66	305.76
February	228.60	5.00	44.87	278.47
March	288.60	24.00	23.31	335.91
April	332.40	35.67	10.55	378.62
May	267.40	.....	38.24	305.64
June	247.90	.50	37.78	286.18
Total	3,163.70	1,621.42	518.00	5,303.12

LOCK No. 2, GREEN RIVER.

1891.				
July	$187.40	$13.25	$26.96	$227.61
August	267.00	5.10	24.74	286.84
September	95.00	8.50	43.82	147.32
October	95.00	127.65	24.98	247.63
November	152.40	46.50	17.73	216.63
December	194.40	26.68	35.32	256.40
1892.				
January	288.60	18.20	15.67	322.47
February	228.60	78.10	17.75	324.45
March	288.60	7.09	23.32	319.01
April	332.40	7.35	10.55	350.30
May	267.40	5.50	11.53	284.43
June	247.90	9.60	44.75	302.25
Total	2,634.70	353.52	297.12	3,285.34

LOCK NO. 3, GREEN RIVER.

1891.				
July	$337.40	$7,253.76	$46.19	$7,637.35
August	245.00	4,770.99	47.62	5,063.61
September	601.00	6,747.58	48.73	7,397.31
October	245.00	4,401.76	53.30	4,700.06
November	302.40	1,111.20	24.73	1,438.33
December	194.40	3.81	65.19	263.40
1892.				
January	288.60	2.00	15.67	306.27
February	228.60	4.25	17.74	250.59
March	288.60	.....	30.82	319.42
April	332.40	16.25	10.55	359.20
May	267.40	328.10	22.97	618.47
June	247.90	1,020.74	56.73	1,325.37
Total	3,578.70	25,660.44	440.24	29,679.38

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Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Green and Barren rivers, Kentucky, improved by locks and dams, etc.—Continued.

LOCK NO. 4, GREEN RIVER.

Months.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.				
July	$312.40	$4,446.74	$25.06	$4,784.20
August	220.00	3,324.08	25.75	3,569.83
September	382.00	2,487.08	43.48	2,912.56
October	611.00	3,002.59	32.66	3,646.25
November	152.40	683.59	17.73	853.72
December	194.40	148.15	34.35	376.90
1892.				
January	288.60	.....	15.67	304.27
February	228.60	190.38	17.74	436.72
March	288.60	1.50	30.82	320.92
April	332.40	8.30	15.35	356.05
May	267.40	12.75	11.53	291.68
June	247.90	.....	45.29	293.19
Total	3,525.70	14,305.16	315.43	18,146.29

LOCK NO. 1, BARREN RIVER.

Months.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.				
July	$92.40	$127.40	$25.71	$245.51
August	95.00	23.95	26.49	145.44
September	95.00	336.35	51.68	483.03
October	257.00	241.25	18.18	516.43
November	543.40	386.35	17.73	947.48
December	194.40	70.10	34.35	298.85
1892.				
January	288.60	2.00	15.67	306.27
February	228.60	.....	17.74	246.34
March	288.60	.....	31.22	319.82
April	332.70	7.00	12.95	352.65
May	267.40	172.03	16.33	455.76
June	247.90	1,084.09	57.66	1,389.65
Total	2,931.00	2,450.52	325.71	5,707.23

UNITED STATES SNAG BOAT WM. PRESTON DIXON.

Months.	Salaries and labor.	Repairs.	Subsistence.	Supplies.	Total.
1891.					
July	$866.17	$16.84	$177.41	$127.48	$1,187.90
August	849.84	.....	173.42	107.07	1,130.33
September	833.67	94.24	120.92	196.96	1,245.79
October	798.84	37.50	187.20	160.95	1,184.49
November	588.66	.....	66.13	112.98	767.77
December	484.50	19.78	.....	5.10	509.38
1892.					
January	435.00	10.85	.....	.....	445.85
February	435.00	45.85	.....	.....	480.85
March	435.00	66.03	.....	.....	501.03
April	462.00	73.30	.....	188.35	723.65
May	629.65	.....	87.43	58.56	775.64
June	475.67	44.75	101.09	162.82	784.33
Total	7,294.00	409.14	913.60	1,120.27	9,737.01

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Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Green and Barren rivers, Kentucky, improved by locks and dams, etc.—Continued.

UNITED STATES DREDGE BOAT LERMOND.

Months.	Salaries and labor.	Repairs.	Supplies.	Total.
1891.				
July	.....	$703.59	$70.32	$773.91
August	$352.70	.....	38.65	391.35
September	320.95	.....	12.50	333.45
October	373.70	.....	24.00	397.70
November	361.70	.....	53.68	415.38
December	100.00	.....	.65	100.65
1892.				
January	145.00	.....	.....	145.00
February	145.00	5.75	.....	150.75
March	145.00	42.38	112.62	300.00
April	145.00	25.60	.....	170.60
May	197.13	.....	48.77	245.90
June	340.60	2.00	60.60	403.20
Total	2,626.78	779.32	421.79	3,827.89

SUMMARY.

Lock No. 1, Green River	$5,303.12
Lock No. 2, Green River	3,285.34
Lock No. 3, Green River	29,679.38
Lock No. 4, Green River	18,146.29
Lock No. 1, Barren River	5,707.23
United States snag-boat *Wm. Preston Dixon*	9,737.01
United States dredge *Lermond*	3,827.89
Grand total	75,686.26

REPORT OF FIRST LIEUTENANT WM. L. SIBERT, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Bowling Green, Ky., June 30, 1892.

MAJOR: I have the honor to submit the following report of operations on Green and Barren rivers, Kentucky, for the fiscal year ending June 30, 1892:

The work on these streams is carried on under the "indefinite appropriation for operating and care of canals and other works of navigation."

WORK DONE.

LOCK AND DAM NO. 1, GREEN RIVER.

Repairs to lock.—Pumped out lock pit; repaired lower mitre wall and placed new upper and lower mitre sills in lock. Removed old apparatus for operating gates and placed new apparatus in position.

General work.—Dredged lock pit and entrances to same. Backed dam with 800 cubic yards of hickory lathe dust.

LOCK AND DAM NO. 2, GREEN RIFER.

Dredged entrances to lock; backed dam with 600 cubic yards of hickory lathe dust; placed 200 linear feet of comb stick on dam; re-covered lock-keeper's dwelling and filled the cellar with sand, the old cellar being always damp.

LOCK AND DAM NO. 3, GREEN RIVER.

Completed repairs to dam by rebuilding the lower slope of a 140-foot section and by blasting off ledge of rock on abutment side and shaping it so as to form a part of dam. By removing the old fore bay, used in running mill on abutment side, and the above ledge of rock, the spill way of dam was increased 85 feet. Five thousand nine hundred cubic yards of stone were quarried and removed from this ledge and utilized in filling dam and guide cribs.

Guide cribs.—Constructed upper and lower guide cribs. Upper river crib is 200 feet long, 34 feet high, and 15 feet wide. Upper land crib is 100 feet long, 12 feet wide, and 10 feet high. Lower river guide crib is 110 feet long, 34 feet high, and its mean width is 13 feet. Lower land crib is 550 feet long; 250 feet of it is 34 feet high, and 300 feet of it is 15 feet high. Total cubic yards of crib work built, 12,497.

Repairs to lock.—Pumped out lock and repaired gates, placing four new arms in each lower gate. Cut down recess for lower gate in old land wall so as to make it vertical. Cut recesses in walls to receive gate castings when gates were opened. Lengthened ladders and cleaned out lock pit. Made more clearance under lower gates by picking off stone forming bottom of lock. Rebolted lower miter sills.

General work.—Drove 29 piles and capped same, forming fender along island above lock. Split up the necessary stone and paved 675 square yards of bank. Moved 1,600 cubic yards of earth in grading bank. Built up wing walls of lock so as to conform to grade of bank. Dredged off point above entrance to lock, and drove forty-five piles around this point for a fender.

Mr. B. O. Lermond, assistant engineer, was in local charge at this lock.

LOCK AND DAM NO. 4, GREEN RIVER.

Repairs to dam.—Removed old sheeting from dam; rebuilt an 80-foot section of lower slope and placed new sheeting on dam throughout. Replaced all missing stone in dam. Constructed and sunk a crib 90 feet long, 16 feet wide, and 22 feet deep, so as to form an apron below the dam next to the abutment and at the same time filling a hole washed out below dam, endangering same. The sheeting has been torn off this crib during the winter, evidently due to a head caused by leak under dam from above.

Guide cribs.—Constructed and repaired guide cribs above and below lock. Lower land guide crib is 275 feet long, average width 12 feet, and 30 feet high. Upper land crib is 140 feet long, 18 feet high, and 15 feet wide. Upper river crib rebuilt from water up, 220 feet long, 10 feet wide, and 10 feet high. Total cubic yards in guide cribs, 5,837.

General work.—Constructed retaining crib along mill race, 450 cubic yards. Split up and laid 408 square yards of paving. Repointed coping of land wall of lock. Placed new gate-operating apparatus in position. Dredged entrances to lock.

Mr. George N. Bratt was in local charge at this lock.

LOCK NO. 7, BARREN RIVER.

Graded bank, Quarried and laid 804 square yards of paving; cut, hauled, and set 1,465 square yards of sod. Set out shade trees and cleaned up premises. Placed 500 cubic yards of sawdust behind dam.

UNITED STATES DREDGE BOAT.

Work done.—Lock No. 1, Green River: Removed 5,621 cubic yards of material and 36 logs from lock pit and entrances to lock.

Lock No. 2, Green River: Removed 5,200 cubic yards of material from entrances to lock.

Lock No. 3, Green River: Removed 12,975 cubic yards of material in preparing foundations for guide cribs and in cleaning out lock entrances and pit. Tore up and removed 6,000 linear feet of old crib timber. Dredged and blasted off remains of old lock wall and cofferdam to low-water level. Dredged a channel across river so as to barge stone from ledge below dam.

Lock No. 4, Green River: Removed 2,920 cubic yards of material from entrances to lock.

General work.—Dredged off point at Boat Island, removing 1,000 cubic yards gravel. Dredged off bar at mouth of Green River, removing 1,000 cubic yards of material. Painted dredge.

UNITED STATES SNAG BOAT WM. PRESTON DIXON.

Removed 1,043 snags from channel of river; cut 252 trees and deadened 220. Pulled out and removed cofferdam at No. 1, Green River. Pulled one dump scow out on ways. Did all towing required on Green and Barren Rivers. Towed a dredge from Mt. Carmel, Ill., to Catlettsburg, Ky. Total miles run 8,773.

Very respectfully, your obedient servant,

WM. L. SIBERT,
First Lieutenant of Engineers.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

Commerce of Green and Barren rivers, Kentucky, for fiscal year ending June 30, 1892.

Articles.	1890.	1891.	1892.	Articles.	1890.	1891.	1892.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
Barrels, empty	55	52	1,268	Merchandise	8,933	16,420	13,093
Beer	1,245	222	92	Produce	501	184	384
Cement	168	600	83	Salt	1,114	1,104	1,376
Coal	45,904	49,000	71,431	Stone	788	14,752	10,742
Flour	733	1,363	1,540	Staves and heading	.....	744	7,841
Grain	1,431	1,284	2,956	Ties, railroad	16,373	21,325	40,736
Handles	227	6,144	605	Tobacco, leaf	4,723	2,164	1,858
Hay	319	427	1,106	Timber, logs, etc	819,920	500,000	283,911
Hides	19	30	233	Whisky	57	43	51
Hoop poles	278	770	4,342	Passengers	972	1,434	1,813
Iron, manufactured	98	253	186				
Live stock	482	1,285	2,056	Total	907,146	628,600	462,208
Lumber	2,866	9,000	14,505				

List of boats plying on Green and Barren rivers, Kentucky.

Name of boat.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
Evansville	Passenger	121	30	5	194.25
Rescue	do	121	26.8	3.4	189.3
J. C. Kerr	do	120	21	3.7	121.15
Blue Wing	do	119	24	4.2	111.82
Fannie	do	85.4	18.4	3.7	80.9
T. C. Woodward	do	65	9	4	33.50
Longfellow	Towboat	112	19.6	4.3	93.59
Eugene	do	113	20	3.5	98.31
D. A. Nisbet	do	105	20	3.6	64.68
Uncle Billy	do	89	18	3	79
D. A. Goodwin	do	103	20.3	3	69
G. B. Monteith	do	103.4	18.2	2.9	62.91
Henry Logan	do	105.8	21	3.5	83.8
Eleanor	do	60	16	2.8	14.64
Little Tom Moss	do	90	22	3	54.3
Emma Cooper	do	95	25	3.5	79.10
Maggie Bell	do	95	18	3	52.80
Emma Erwin	Tugboat	79	15	4.4	41.84
Isabella	do	95	22	4.8	66.24
Louise	do	76	16.5	3.8	40.80
Ingleside	do	81	14	4	36
Orphan Girl	do	80	15	4	39
Uncle Buck	do	67	18	4	32.34
Montezuma	do	49	12.1	3.5	16.19
United States snag boat Wm. Preston Dixon.	Snag boat	123.6	32	5	200

Report of lockages on Green and Barren Rivers, Kentucky, for fiscal year ending June 30, 1892.

Locks.	Days operated.	Days suspended.	Going up.			Going down.				Total crafts and flats passing.	Total number lockages.
			Steamboats.	Barges and flats.	Miscellaneous.	Steamboats.	Barges and flats.	Rafts.	Miscellaneous.		
Green River:											
No. 1	311	54	394	230	106	393	219	898	78	2,318	2,682
No. 2	328	37	321	151	4	313	121	785	2	1,697	2,169
No. 3	328	37	251	155	115	241	150	426	97	1,435	1,731
No. 4	345	20	306	135	68	313	141	208	61	1,232	1,421
Barren River:											
No. 1	361	4	281	97	11	274	83	36	19	801	794
Total	1,673	152	1,553	768	304	1,534	714	2,353	257	7,483	8,797

Navigation through Locks Nos. 2 and 4, Green River, and No. 1, Barren River, were suspended only for high water. Navigation was suspended for repairs ten days at Lock No. 1, Green River, and thirteen days at Lock No. 3, Green River.

G G 3.

IMPROVEMENT OF ROUGH RIVER, KENTUCKY.

Rough River is a tributary of Green River, emptying into it at a point 71 miles from its mouth, and 8 miles above Lock No. 2, at Rumsey.

Shortly after the war a company built a timber and stone lock, with dam and abutment, about 8 miles from the mouth of the river, and steamboats from 110 to 125 feet long ran up the river as far as Hartford, until the Green and Barren river improvements were leased to the Green and Barren River Navigation Company by the State of Kentucky. It is claimed that the excessive tolls charged by the navigation company effectually killed the commerce of Rough River, and the lock and dam were abandoned. The dam was only 90 feet long, and shortly afterward the river went around the abutment. Eventually the dam was torn out, so that now nothing but the ruins of the old lock remain.

The river was very much obstructed at the time work on it was commenced, and being narrow and very crooked, some of the bends were almost filled with snags, sunken timber and logs, while overhanging trees on the banks constituted a still further obstruction to steamboats.

The project for its improvement was approved October 27, 1890, and provides as follows: First. To definitely locate the site of the lock proposed, and purchase or have condemned the land needed about the lock and abutment. Second. Clear the river of obstructions, to wit: Overhanging trees on the banks, and snags, logs, and stumps in the bed of the river. The estimate for this was $300 per mile, or $9,000 for the 30 miles between the mouth of the river and Hartford. It is thought that the land needed about the lock and abutment can be purchased for from $30 to $40 per acre.

As overhanging trees, if cut into the river, would in many cases sink and cause worse obstructions than when standing, only those that could be cut into short lengths or pulled up on the banks have been felled, others were merely deadened by girdling and will be cut down when dead and allowed to float away.

The location plans, etc., of the proposed lock were approved by the Chief of Engineers under date of August 31, 1891. The site of the lock is near that of the old one, 8 miles from the mouth of the river. The principal figures in connection with it are as follows:

	Ft.	in.
Length over all	191	6
Length between hollow quoins	145	9
Height of walls	25	8
Lift	9	
Height of dam	15	6
Guard of lock	8	
Depth of water on lower miter sill	4	
Depth of water on upper miter sill	6	8

The land required on the lock side of the river has been surveyed, as well as that required on the abutment side, and a deed prepared for the first tract was submitted for approval under date of February 20, 1892.

As the wife of the owner of the land on the abutment side is in a lunatic asylum, this tract will have to be condemned in the proper courts. For information as to details of work done during the fiscal year ending June 30, 1892, attention is invited to the report of First Lieut. Wm. L. Sibert, Corps of Engineers, herewith.

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APPROPRIATIONS.

September 19, 1890 ..... $25,000

Money statement.

July 1, 1891, balance unexpended	$24,291.46
June 30, 1892, amount expended during fiscal year	5,123.50
July 1, 1892, balance unexpended	19,167.96
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	34,167.96
Amount (estimated) required for completion of existing project	65,556.05
Amount that can be profitably expended in fiscal year ending June 30, 1894	65,556.05

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF FIRST LIEUTENANT WILLIAM L. SIBERT, CORPS OF ENGINEERS.

SIR: I have the honor to submit the following report of operations on Rough River, Kentucky, for the fiscal year ending June 30, 1892:

That portion of the project which consisted in deadening the leaning timber along the banks and removing the obstructions from the channel of the stream, from the mouth to Hartford, Ky., has been completed.

No work has been done on projected lock.

Work done.—Deadened, 29,499 trees; cut up, 3,260 tree tops on banks and 1,684 in the river; cut up, 2,815 logs on bank; removed, 5,637 snags from river; cut, 839 leaning trees; trimmed, 209 trees, and removed, 8 cubic yards of stone from channel of river.

Very respectfully, your obedient servant,

WM. L. SIBERT,
First Lieutenant of Engineers.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Commerce of Rough River, Kentucky, for fiscal year ending June 30, 1892.

Articles.	1891.	1892.
	Tons.	*Tons.*
Logs	89,161	.....
Lumber	9,000	.....
Timber, logs, etc	.....	50,000
Total	98,161	50,000

List of boats plying on Rough River, Kentucky.

Name.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
Uncle Buck	Tug	67	18	4	30.34

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G G 4.

IMPROVEMENT OF KENTUCKY RIVER, KENTUCKY.

The Kentucky River is a tributary of the Ohio, and empties into it at Carrollton, Ky., about midway between Cincinnati, Ohio, and Louisville, Ky.

The present project for the improvement of the river was adopted in 1879, the object being to repair the five locks and dams built by the State of Kentucky, and extend slackwater navigation for a draft of 6 feet, by the construction of additional locks and dams to Beattyville, a distance of 261 miles from the mouth of the river.

WORK DONE DURING THE YEAR.

Lock No. 6.—Work on this lock was commenced April 27, 1891, by excavating for lock walls, and on December 2 the first boat was locked through. The cofferdam inclosing the lock site consisted in the main of a row of piles joined by stringers and wale pieces, against which a double row of sheet piles was driven, the whole being backed inside and out with gravel put in position by dredges. The lower return wing to the bank was left open at first, so that excavation of the inclosed area could be effected by the dredges. Afterwards the lower return wing to the bank was constructed, the inclosed area pumped out, and excavation to the rock made by shoveling, wheeling out the material, or hoisting it out with derricks. Although the coffer was flooded three times during the season, it held well, leaked very little, and answered every purpose.

In the construction of the lock and abutment, the following quantities of stone, etc., were put in place:

	Cubic yards.	Cubic feet.
Coping stone	439	23
Special stone	693	25
Dressed face stone	1,830	5
Quarry face stone	1,557	26
Squared stone	1,287	1
Backing stone	3,999	20
Foundation stone	1,420	18
Spawls and riprap	2,028	2
Concrete	1,483	26
Grout	1,836	19

The dimensions of the lock are as follows: Length of walls, 249 feet. Length of chamber between hollow quoins, 185 feet. Width of chamber, 52 feet. Lift, 14 feet 2½ inches.

Nearly all the stone was on hand when the work commenced.

In the construction of the dam the lower step is a crib filled with stone extending down to the rock and reaching from the abutment to the river wall of the lock. The portion of the dam extending upstream above the lower step is crib work, resting on 139 piles, and is also filled with rock. The upper breast of the dam is protected by a double row of sheet piling extending down to the rock, and will be backed with gravel.

In the construction of the dam the following material was used: 680,880 feet, B. M., timber, 291,217 feet, B. M., sheathing, 16,361 cubic yards stone, 2,235 cubic yards fascines, and 10,949 cubic yards sand,

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clay, and gravel as backing to dam. The length of the dam is 412 feet and the width of base 60 feet.

When it could be done to advantage work was carried on continuously, day and night. Assistant Engineer R. S. Burnett was in charge of the work of construction, and is entitled to great credit for the intelligent and effective manner in which the work was carried on. For details of work done, etc., attention is invited to his report, attached hereto.

Beattyville Dam.—This dam, which had in previous years been cut down to the level of the second step, was extended through the cofferdam to the Proctor side of the river. The object of this dam is to furnish a pool extending up to the Middle Fork of the Kentucky to give light-draft navigation between Beattyville and the Kentucky Union Railroad during low water. The water in the upper part of this pool is very shallow during extreme low water, and it may be necessary to build four or five low wing dams to concentrate the water and give a slightly increased depth.

Lock No. 7.—In the surveys made for locating locks and dams above No. 6, the lowest location for No. 7 was at Shakers Ferry or High Bridge; others were made above that point.

It appears from recent investigation that Cow Shoal, just below Shakers Ferry, was practically overlooked and before definitely locating No. 7, this locality will have to be carefully examined. It may be that the proper depth, 6 feet at pool water, over this shoal, may be secured by constructing small wing dams to narrow the low-water channel, but if this can not be done the location of the lock will have to be made lower downstream.

The large mass of rock that in former times had slid into the river from the cliff at a point near Brooklyn was removed. Two thousand nine hundred and forty-seven cubic yards of rock and bowlders were blasted and removed, and 852 cubic yards of sand, gravel, and mud.

Snag boat Kentucky.—This boat, originally called the *Kwasind*, was built for the Wabash River in 1879. In 1884 she was temporarily transferred to the improvement of the Kentucky River. Afterwards she was purchased for that river, the price paid being $1,000. In 1886 the boat was practically rebuilt, a hull with iron gunwales and bulkheads being substituted for the old wooden hull, and the old upper works retained; new cylinders, 12-inch bore, were put in.

The boat is now in such condition that I do not deem it sound economy to spend any more money on repairing her. She requires a new bottom throughout; new forecastle deck; the timber of the butting beam forward, requires removal, and her upper works are in bad shape. Her boilers, which are 13 years old, have been condemned, practically, by the steamboat inspectors; they let down three times last season and were repaired by putting in new sheets and patching. The repairs that she must have made on her, including new boilers, to render her at all serviceable, will cost about $4,500 or $5,000. She has not power enough; she is awkward to handle, having a square bow, and is in no degree suited for the work required of a steamboat under the new conditions that exist on the Kentucky River. It must be remembered that there are now six instead of four locks in the slackwater system.

In building No. 7, and other locks above, a regular towboat of high power is required, especially if the stone just below Beattyville is to be used in the construction of the next lock. In my opinion, the *Kentucky* should be sold for what she will bring, and a new boat built to take her place, one that can be of service in the general work of fur-

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ther improvement of the river, and at the same time, when necessary, be of service in snagging and doing general work connected with operating and care. The present boat can not do the work.

APPROPRIATIONS.

March 3, 1879	$100,000
June 14, 1880	100,000
March 3, 1881	125,000
August 3, 1882	225,000
July 5, 1884	250,000
August 5, 1886	187,500
August 11, 1888	180,000
September 19, 1890	180,000
	1,347,500
Received from Tabler & Cogar	500
	1,348,000

Money statement.

July 1, 1891, balance unexpended	$151,816.59
June 30, 1892, amount expended during fiscal year	147,834.43
July 1, 1892, balance unexpended	3,982.16
July 1, 1892, outstanding liabilities	2,128.03
July 1, 1892, balance available	1,854.13
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	151,854.13
Amount (estimated) required for completion of existing project	1,524,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. R. S. BURNETT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Frankfort, Ky., July 1, 1892.

MAJOR: I respectfully submit the following report on the improvement of the Kentucky River, Kentucky, for the fiscal year ending June 30, 1892:

LOCK NO. 6.

ABUTMENT.

History.—Began excavating for abutment May 16. Completed excavating June 27. Began setting stone June 5. Completed setting stone July 2. Set 7 cubic yards (21 cubic feet) of coping on return wing into bank. The return wing into bank was raised 7 feet 6 inches by stepping back 6 feet 5 inches from face of abutment six steps 2 feet 5 inches in length, rise 15 inches each.

LOCK.

History.—Began excavating for foundation April 27. Completed excavation June 27. Began setting stone for foundation July 6. Completed foundation July 26. Began setting cut stone for lock walls July 27. Completed setting stone October 24, 1891.

Dimensions of work done.—Length of foundation on river-lock wall, 254 feet. Depth, 7 feet 9 inches. Width, 24 feet.

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Length of upper-miter wall, 50 feet. Depth, 7 feet 4 inches. Width, 48 feet.

Length of lower-miter wall, 50 feet; average depth. 3 feet 10 inches to solid rock.

Length of shore-lock wall to solid rock on level with footing course of masonry, 60 feet. Depth up-river end, 7 feet 4 inches to level of solid rock 60 feet down river. Width, 18 feet.

Excavation.—Dredge *Willie* dredged 7,082 cubic yards of sand, clay, earth, and gravel for shore-lock walls, and 13,284 cubic yards of sand, clay, and gravel for river-lock wall.

Dredge *Ward* dredged 3,112 cubic yards of sand, clay, earth, and stone for shore-lock wall. Four thousand one hundred and ninty seven cubic yards of sand, clay, and gravel for river-lock wall.

By picking, shoveling, wheeling, and hoisting, 21,472 cubic yards of sand, clay earth, and mud.

Total amount of material excavated for all walls, 49,147 cubic yards.

Statement of stone used in lock.—Set the following amount of stone:

	Cubic yards.	Cubic feet.	Cubic inches.
Coping stone	439	25	11
Special stone	693	25	1
Dressed face	1,830	5	8
Quarry face	1,557	26	6
Squared stone	1,287	1	2
Foundation stone	1,420	18	0
Backing stone	3,999	20	0
Concrete	1,483	26	0
Spawls and riprap stone	2,028	2	0
Grout	1,836	19	0
Total amount stone, etc	16,578	7	4

Stonework—Rehandled and assorted 6,842 cubic yards; 25 cubic feet of cut stone in stone yard.

Filling.—Placed behind shore-lock wall, 4,243 cubic yards of earth, clay, spalls, and riprap stone.

Stonework.—Inspected and loaded cut stone at Louisville, Ky.; towed same to Lock No. 6. Recut special, dressed-face, quarry-face, and squared-face stone. Cut and leveled backing in lock walls. Drilled lewis holes in special and dressed-face stone. Cut closures and checks in stone; rounded stone for ladder ways and corners of lock walls. Cut, drilled, and trimmed holes in culvert stone for wicket frames. Cut channels and drilled holes for anchor rods and bolts for upper and lower lock gates. Cut and trimmed manholes in river and shore lock walls. Drilled holes for fastening miter and mud sills. Cut and rounded corners of steps for upper and lower wing walls. Trimmed stone for grates covering wicket shafts. Cut and drilled holes for capstans and placed same in position. Drilled four holes for check posts and placed same in position. Bolted all ladders in ladder ways. Placed in position all wickets, wicket frames, shafts, screens, and housings, etc.

Trestles.—Placed iron trestles in position between mud and miter sills.

Upper and Lower Lock Gates.—Dressed and painted lumber; framed, completed, and hung gates in lock walls. Placed operating irons in position Used 63,904 feet B. M. long-leaf yellow pine in construction of gates.

Lock entrance.—Dredge *Willie* dredged 500 cubic yards of sand, clay, and gravel.

Dredge *Ward* dredged 12,723 cubic yards of sand, clay, and gravel.

DAM.

History.—Began excavating June 13; completed excavating October 10. Began laying timbers September 2. Completed dam November 21. Length of dam, 412 feet; width of dam, 60 feet.

Excavation.—Excavated to an average depth of 18 feet from the abutment to the cofferdam, 350 feet in length and 25 feet in width. Removed from the face and upper end of abutment 1,495 cubic yards of earth and clay.

Dredge *Ward* dredged 20,010 cubic yards of clay and gravel. Dredge *Willie* dredged 8,677 cubic yards of sand, clay, and gravel.

Removed by picking, shoveling, and wheeling 645 cubic yards of sand, clay, and earth.

Piling.—Drove 139 piles, 2,877 linear feet for cribbing, 8 by 10 feet between abutment and cofferdam, to an average depth of 15 feet, the full width of the dam.

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Timbers.—Constructed crib 18 feet wide, 18 feet high, and 350 feet long from the abutment to the cofferdam; sunk same with riprap stone to solid rock.

Laid the following amount of timber:

		Feet, B. M.
57	pieces 12 by 12 inches by 10 feet	6,840
728	pieces 12 by 12 inches by 16 feet	139,776
618	pieces 12 by 12 inches by 20 feet	148,320
649	pieces 12 by 12 inches by 24 feet	186,912
171	pieces 12 by 12 inches by 30 feet	61,560
358	pieces 12 by 12 inches by 32 feet	137,472
2,581		680,880

Sheathing.—Spiked the following oak sheathing on dam:

Oak lumber—	Feet, B. M
2-inch	24,216
3-inch	66,291
5-inch	560
6-inch	34,524
9-inch	165,626
	291,217

Spikes.—Used the following amount of spikes:

Spikes—	
⅝ by 6 inches	5,200
¾ by 8 inches	1,833
¾ by 12 inches	68
¾ by 16 inches	11,105
¾ by 24 inches	2,299
	20,505

Stone.—Placed 16,361 cubic yards 8 cubic feet of riprap stone in cribbing.

Backing.—Placed 10,949 cubic yards of sand, clay, and gravel, and 2,235 cubic yards of fascines behind dam.

UPPER SHORE GUIDE WALL.

Excavation.—Removed by picking, shoveling, wheeling, and hoisting, 2,586 cubic yards of sand, clay, earth, and gravel to solid rock for foundation.

Piling.—Drove 32 piles, aggregating 293 linear feet.

Timber laid.—Laid the following amount of timber:

		Feet, B. M.
17	pieces 6 by 12 inches by 16 feet	1,632
184	pieces 12 by 12 inches by 16 feet	35,328
172	pieces 12 by 12 inches by 20 feet	41,280
135	pieces 12 by 12 inches by 24 feet	38,880
20	pieces 12 by 12 inches by 30 feet	7,200
46	pieces 12 by 12 inches by 32 feet	17,664
574	pieces.	141,984

Spikes.—Used the following number of spikes:

Spikes:	
¾ by 12 inches	50
¾ by 16 inches	1,026
¾ by 24 inches	114

Stone.—Placed 846 cubic yards of riprap stone in cribbing.

Filling.—Placed behind wall 212 cubic yards of riprap stone.

Dimension of wall.—One hundred and forty-three by 16 feet. Foundation of wall, 24 feet.

LOWER SHORE GUIDE WALL.

Excavation.—Removed by picking, shoveling, wheeling, and hoisting, 3,477 cubic yards of sand, clay, earth, and gravel. Blasted 165 cubic yards of solid rock for foundation, 24 feet wide.

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Timber.—Laid the following amount of timber:

	Feet, B. M.
1 piece 12 by 12 inches by 10 feet	120
96 pieces 12 by 12 inches by 16 feet	18,432
16 pieces 12 by 12 inches by 20 feet	3,840
39 pieces 12 by 12 inches by 24 feet	11,232
1 piece 12 by 12 inches by 30 feet	360
2 pieces 12 by 12 inches by 32 feet	768
155 pieces.	34,752

Spikes.—Used the following number of spikes:

Spikes:	
¾ by 16 inches	580
¾ by 24 inches	157

Stone.—Placed 50 cubic yards of stone in cribbing.

Filling.—Placed behind wall, 159 cubic of riprap stone.

Dimension of wall.—One hundred and fifteen by 16 feet. Foundation, 24 feet wide.

Counterfort return wing walls into the bank at upper and lower end of inside lock wall:

Foundation.—The foundation of these walls are on solid rock and bonded into the shore lock wall.

Dimension.—Length of wing walls, 35 feet 5 inches.

Width of walls at foundation, 12 feet; width at top, 5 feet. The walls were raised 6 feet 8 inches, in 5 steps, above lock wall, by stepping back from back face of lock wall 7 feet 1 inch, with a rise of 16 inches to each step.

CARPENTER WORK.

Traveler trestles.—Built two foundations for traveler trestles, for setting stone on inside lock wall, 260 feet long by 18 feet wide; average height, 3 feet; one foundation, 260 by 5 by 3 feet.

Dimensions.—(1) Trestle, 260 feet long, 34 feet high, and 18 feet wide; (1) trestle, 260 feet long, 34 feet high, and 5 feet wide. Laid 1,040 linear feet of 4 by 12 inch oak stringers and 1,560 linear feet of 2 by 12 inch oak on trestles and braced same.

Tramway trestles.—Built the following trestles for tramway:

	Length.	Width.	Height.		Length.	Width.	Height.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
1 trestle	135	14	8	1 trestle	40	18	4
Do	340	9	14	do	126	12	8
Do	35	12	14	do	20	9	16
Do	96	6	5	1 trestle (switch)	20	6	8

Laid 1,678 linear feet of 4 by 12 inch oak stringers; 1,998 linear feet of 2 by 12 inch oak stringers on same and braced trestles. Built trestle from river bank to cement shed; built trestle for rolling cement from cofferdam to lock walls, 40 feet long, 9 feet wide, and 16 feet high.

General carpenter work.—Built 10 platform foundations for engine and pumps and braced same; built shed over engine, 16 by 24 feet, in cofferdam; built cover over belt 18 feet long, 4 feet wide, and 5 feet high; made and placed in position 2 small derricks on barges; set up pile-driver in cofferdam; made 2 floats, 60 by 4 feet; made bucket pump, 12 feet long; constructed water trough 12 by 14 by 14 feet and 1 barrow run, 100 feet long; built grating around suction pump to prevent gravel getting in pump, 20 feet long, 5 feet high; made skids 50 feet long, used in removing lock gates from bank to river; made 4 check posts, 8 feet long, 9 inches by 12 inches; 1 stone chute 12 feet wide by 14 feet long; 1 scaffold 20 feet long and 22 feet wide; 2 mud sills and 2 miter sills; 1 closet in carpenter shop; 4 shelves in tool house; 2 water gauges; 2 carpenter benches; 1 spud for dredge *Ward*, 26 feet long, 11½ by 11½ inches, and placed same in position; made patterns for special stone and lock gates; 1 stiff leg, 20 feet long, for derrick boat; 4 derrick seats; 7 stiff legs; 12 booms; 9 masts; 2 booms and 1 mast seat; 11 mud scrapers; 42 centers for culverts; 4 horse-power sweeps; 10 timber trucks; 4 plumb rules; 4 ladders, 16 feet long; 5 hods; 2 hoe handles; 9 auger handles; 99 hammer handles; 3 ax handles; 10 barrow handles; 25 cant-hook handles; 14 oars; 1 cavil; 1 chock for derrick boat; 11 pike poles; 22

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car frames; 14 car brakes; 16 stone hammers; 12 derrick cavils; 1 desk; 2 tables; 3 tool boxes; 3 hoisting trays; 4 mortar hocks; 3 dump boxes; 18 straight edges; 2 pulleys, 2 inches in diameter; 5 windows; 5 door screens; 1 grind-stone frame; 8 mortar boxes; 2 coal boxes; handled 50 picks, 23 adzes, 82 axes, 16 mattocks, 65 hammers. Repaired derrick boat, flatboats, dredges *Ward* and *Willie*, barges, skiffs, 104 barrows, 3 car frames.

Derricks.—Made foundations, raised, rigged, and placed in position 18 derricks on lock side of river; 3 derricks on abutment side of river; 6 derricks in and 3 on platform in cofferdam; 2 large and 2 small derricks on barges for handling timbers, sheating, and stone; moving and changing derricks during the progress of the work, as required.

UNITED STATES SNAG BOAT KENTUCKY.

The United States snag boat *Kentucky* towed barges loaded with material for the construction of the lock from Frankfort, Ky., to the lock. Handled dredges, derrick boat, scows, etc. Hoisted 10,000 feet, B. M., of sunken hewed timber from river to bank; 750 linear feet of piling from river to bank; 9,440 feet, B. M., of hewed timber and 17,696 feet, B. M., of sheathing from cofferdam to barge, removed same to dam and unloaded. Removed derricks, derrick foundations, and platform from cofferdam to river bank; removed 40 feet of lower end of cofferdam. General work about coffer-dam, abutment, lock, and dam.

STEAMER L. A. FULTON.

The steamer *L. A. Fulton* was chartered July 23 to September 14, 1891, to take the place of the United States snag boat *Kentucky* while the latter had her boilers repaired.

Towed cut stone from Louisville, Ky., to Lock No. 6. Removed with scrapers from shore lock wall 525 cubic yards of mud. Acted as tender for dredge *Ward*, derrick boat, barges, scows, etc., and general work around lock.

UNITED STATES DERRICK BOAT.

The United States derrick boat unloaded cement and other material for the works. Drove piles to fasten guy lines, and constructed foundations in river for derricks, etc. Drove piling for dam; assisted in removing cofferdam from upper and lower entrance of lock. Handled cut stone for lock walls; handled cement and riprap stone for filling dam, and did general work around lock and dam.

UNITED STATES DREDGE BOAT WARD.

The United States dredge boat *Ward* dredged the following amount of material: For lock walls, 7,309 cubic yards of sand, clay, gravel, and stone; for dam, 20,010 cubic yards of sand, clay, and gravel; for lock entrances, 12,723 cubic yards of sand, clay, and gravel; removed dipper and dipper handle, and replaced same with new; removed 1 spud 26 feet long, 11½ by 11½ inches.

Broke the following, and replaced same: 1 dipper, 1 dipper handle, 1 spud, 2 cam rods, 1 clutch, 2 pinion wheels, 1 driving wheel, 1 junction band, 1 lever, 1 pump cylinder, 8 10-inch bolts, 7 12-inch bolts; broke backing chain eleven times, hoisting chain once.

UNITED STATES DREDGE BOAT WILLIE.

United States dredge boat *Willie* dredged the following amount of material: For lock walls, 20,266 cubic yards of sand, clay, and gravel; for dam, 8,677 cubic yards of sand, clay, and gravel; for lock entrances, 500 cubic yards of sand, clay, and gravel.

Broke the following, and repaired same: 1 screw in latch of dipper, 1 stand for set screw; broke backing chain once.

OBSTRUCTIONS IN RIVER AT BROOKLYN, KENTUCKY, POOL NO. 6.

Complying with your instructions, work was commenced in August, 1891, removing the rock that had slipped some years ago from the bluff into the channel of the river. This work has given a depth of not less than 8 feet over the area that had been obstructed.

The following is a statement of work done:

Blasted and removed 2,947 cubic yards of rock and bowlders; removed 852 cubic yards of sand, gravel, and mud.

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BEATTYVILLE DAM.

Extending fixed dam, through the cofferdam, across the old passes to the Proctor Bluff.—The work of extending the fixed dam at the level of the second step through the cofferdam and old passes to Proctor Bluff was continued.

The following is a statement of work done:

Material removed from interior of cofferdam:		
Mud, sand, and gravel	cubic yards	339
Riprap stone	do	24
Old hewed oak timber	linear feet	1,389
Sawed oak lumber	feet B. M.	2,106
Assorted spikes		736
Upper breast sheathing	feet B. M.	1,800
Clay backing to old breast of dam	cubic yards	395
Material removed from river guide wall to level of first and second steps of dam:		
Riprap stone	cubic yards	326
Oak sheathing	feet B. M.	18,256
Hewed oak timber	linear feet	3,800
Sand and mud	cubic yards	464
Oak waling	linear feet	98
Oak piles		10
Assorted spikes		1,262
Material removed from up and down river face of cofferdam:		
Mud, sand, and gravel	cubic yards	2,031
Riprap stone	do	222
Clay puddle	do	697
Covering boards	linear feet	1,190
Oak bracing	do	213
Hewed oak timber	do	7,113
Oak piling	do	2,021
Oak waling	do	590
Oak sheet piling	feet B. M.	28,820
Assorted iron tie-rods		31
¾-inch iron chain	linear feet	26

Material used in extending fixed dam through cofferdam.—The following material was used in extending fixed dam through cofferdam: Laid 7,527 linear feet of oak hewed timber; laid 23,500 feet B. M. 9-inch oak timber as grillage; laid 3,994 feet B. M. 9-inch oak timber as grillage; placed 1,044 cubic yards of riprap stone; placed 26,420 feet B. M. 2 by 3 inch oak sheathing; placed 774 cubic yards of clay behind breast sheathing; placed 6,515 feet B. M. oak lumber upper breast sheathing; placed 57 cubic yards stone behind breast of dam; 3,860 spikes, assorted.

Repairs to old fixed dam.—The old fixed dam having been damaged by freshets, the following work was done: Removed 1,907 linear feet of hewed oak crib timber; removed 16,633 feet B. M. 3 by 9-inch oak sheathing; removed 109 cubic yards of sand, clay, and gravel; removed 83 cubic yards of riprap stone; placed 995 linear feet hewed oak timber; placed 5,650 feet B. M. 9-inch oak sheathing; placed 20,193 feet B. M. 3-inch oak sheathing; placed 287 cubic yards riprap stone; placed 175 cubic yards of clay and gravel as backing; respiked old step sheathing of dam.

Abutment.—Heavy rains and freshets had scoured the bank at the upper return wing of the abutment.

The following material was used in repairing the same: 288 feet B. M. oak sheathing, 149 cubic yards riprap stone, 181 barrels of cement (solidified).

General work.—Hauling, handling, and stacking hewed timber; quarrying stone; constructing cofferdam around gaps in cofferdam; mixing and placing concrete; removing and assorting old spikes from hewed timber; pumping, watching, and care of Government property.

ROCK SHOAL QUARRY.

But slight damage has been done to lock stone stacked at this quarry. On the 17th of May, 1892, the powder house and one small office building were damaged by the bank at quarry slipping into the river.

Respectfully submitted.

R. S. BURNETT,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

Commerce of Kentucky River, Kentucky, for fiscal year ending June 30, 1892.

Articles.	1890.	1891.	1892.	Articles.	1890.	1891.	1892.
	Tons.	*Tons.*	*Tons.*		*Tons.*	*Tons.*	*Tons.*
Beer			345	Logs	158,903	224,844	72,749
Brick			130	Lumber	10,670	15,256	13,336
Coal	89,562	89,752	203,224	Merchandise, miscellaneous	19,554	21,739	60,618
Cement			200	Salt	909	1,602	9,025
Cooperage			736	Timber	4,682	3,761	21,831
Cross-ties			1,445	Tobacco	2,783	5,636	11,199
Grain	6,991	14,279	10,219	Whisky	4,142	4,306	4,098
Flour	1,503	1,744	6,233	Passengers	1,995	2,023	3,1 2
Hay	4,407	500	6,488				
Iron	1,903	712	4,292				
Live stock	2,350	3,065	2,506	Total	310,354	389,219	431,846

List of stern-wheel boats plying on the upper Kentucky River, Kentucky.

Name of boat.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
Favorite	Packet	169	15	3	43.64
Ada V	do	92	13.6	2.2	21.32

G G 5.

OPERATING AND KEEPING IN REPAIR THE SIX LOCKS AND DAMS ON KENTUCKY RIVER, KENTUCKY.

The United States acquired possession of these locks and dams in 1880, at which date they were in a more or less crippled condition, the timber of the dams being badly decayed and the lock gates and operating machinery in such a state as to need absolute removal or extensive repairs.

Some of the dams have been entirely rebuilt, the others nearly so. Guide walls above and below the locks have been constructed, and the banks about the locks and abutments protected by timber cribbing to prevent erosion.

New lock-keepers' houses have been built, the areas in rear of the land walls graded and paved, and the grounds graded, sown with grass seed, and fenced.

With the completion of Lock and Dam No. 6, slack-water navigation was extended to High Bridge, which is 121 miles above the mouth of the Kentucky.

During the past fiscal year general repairs have been made to the dams, such as replacing sheeting torn off by drift, and placing backing behind the upper breasts to stop leaks, etc.

The general repairs to the locks have consisted in replacing defective coping, and repairing gates by putting in new blocks and arms. When necessary the entrances have been dredged, so as to afford navigation equal to the full depth on the lower miter sills, and the guide and protection cribs about the entrances have been kept in repair.

The river has been kept free from snags by the United States snag boat *Kentucky*, which, although belonging to the general improvement of the Kentucky River, is yet a large part of the time operated under the indefinite appropriation for operating and care of canals, etc., applied to Kentucky River, Kentucky. In her present condition this boat is far from being effective.

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An additional lock-keeper's dwelling is required at Lock No 2.

With the exception of No. 5, which needs backing badly, all the dams are in an effective condition for low water. The crib that formerly extended downstream below the abutment of No. 1 will be rebuilt at once, high water in the Ohio having delayed work on it until now. For details concerning the work done during the past year, attention is invited to the report of Assistant Engineer R. S. Burnett, herewith:

ALLOTMENTS.

1885	$15,000.00
1886	24,000.00
1887	35,133.60
1888	82,308.54
1889	82,478.50
1890	72,394.80
1891	28,889.07
1892	48,826.68
Total	389,031.19

Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Kentucky River, Kentucky, improved by locks and dams, during the fiscal year ending June 30, 1892.

Months.	Lock No. 1.				Lock No. 2.			
	Salaries.	Labor and material.	Current and contingent expenses.	Total.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.								
July	$213.00	$5.25	$4.95	$223.20	$213.00	$43.90	$4.95	$261.85
August	233.00	71.31	1.40	305.71	233.00	6.40	1.40	240.80
September	159.00	177.22	12.55	348.77	165.00	187.49	1.40	353.89
October	229.00	162.40	17.22	408.62	229.00	134.50	17.23	380.73
November	227.00	12.30	6.94	246.24	227.00	.....	6.94	233.94
December	233.00	2,839.23	9.75	3,081.98	233.00	.....	.....	233.00
1892.								
January	186.66	783.43	.....	970.09	186.66	9.30	.....	195.96
February	153.33	2,412.83	.....	2,566.16	153.33	6.05	.....	159.38
March	153.33	161.25	2.40	316.98	153.33	.....	2.40	155.73
April	153.33	148.59	.....	301.92	153.33	1.00	.....	154.33
May	207.49	119.00	1.09	327.58	207.49	.....	1.09	208.58
June	203.33	513.88	11.71	728.92	203.33	90.95	11.61	305.89
Total	2,351.47	7,406.69	68.01	9,826.17	2,357.47	479.59	47.02	2,884.08

Months.	Lock No. 3.				Lock No. 4.			
	Salaries.	Labor and materials.	Current and contingent expenses.	Total.	Salaries.	Labor and materials.	Current and contingent expenses.	Total.
1891.								
July	$213.00	$96.20	$4.95	$314.15	$213.00	$3.00	$4.96	$220.96
August	233.00	59.05	1.40	293.45	233.00	43.85	1.40	278.25
September	165.00	153.08	1.40	319.48	120.00	954.84	1.40	1,076.24
October	229.00	63.10	17.23	309.33	229.00	114.47	18.03	361.50
November	227.00	.....	6.94	233.94	227.00	79.90	6.95	313.85
December	233.00	5.56	.....	238.56	233.00	11.60	.....	244.60
1892.								
January	186.66	4.90	.....	191.56	186.66	44.95	.....	231.61
February	153.33	30.00	.....	183.33	153.33	1.50	.....	154.83
March	153.33	26.40	2.40	182.13	153.33	56.85	2.40	212.58
April	153.33	59.10	.....	212.43	153.33	209.58	.....	362.91
May	207.50	31.95	1.08	240.53	207.50	112.95	1.08	321.53
June	203.33	119.60	11.62	334.55	203.33	156.20	9.72	369.25
Total	2,357.48	648.94	45.12	3,053.44	2,312.48	1,789.69	45.94	4,148.11

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***Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Kentucky River, Kentucky, improved by locks and dams, etc.*—Continued.**

Months.	Lock No. 5.				Lock No. 6.			
	Salaries.	Labor and material.	Current and contingent expenses.	Total.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.								
July	$213.00	$110.00	$29.28	352.28	.....	.....	.....	.....
August	233.00	48.10	1.40	282.50	.....	.....	.....	.....
September	165.00	97.70	6.30	269.00	.....	.....	.....	.....
October	229.00	374.56	17.23	620.79	.....	.....	.....	.....
November	227.00	115.30	6.95	349.25	.....	.....	.....	.....
December	233.00	50.36	.....	283.36	$95.00	$27.92	.....	$122.92
1892.								
January	186.68	1.80	.....	188.48	186.68	182.55	14.40	383.63
February	153.34	9.20	.....	162.54	153.34	.....	.....	153.34
March	153.34	.....	2.40	155.74	153.34	56.78	2.40	212.52
April	153.34	72.00	.....	225.34	153.34	131.72	.....	285.06
May	207.51	89.85	1.08	298.44	207.51	11.40	1.08	219.99
June	203.34	165.35	14.47	383.16	203.34	106.60	25.32	335.26
Total	2,357.55	1,134.22	79.11	3,570.88	1,152.55	516.97	43.20	1,712.72

Months.	United States snag boat Kentucky and steamer Fulton.				United States dredges Willie and Ward.			
	Salaries and labor.	Repairs.	Supplies.	Total.	Salaries and labor.	Repairs.	Supplies.	Total.
1891.								
July	$973.50	$79.44	$452.71	$1,505.65	$407.78	$52.88	$6.15	$466.81
August	1,021.00	.....	450.45	1,471.45	290.00	11.20	58.91	360.11
September	959.49	16.90	548.61	1,525.00	.....	.....	51.35	51.35
October	936.82	.....	199.28	1,136.10	433.38	451.06	.....	884.44
November	948.50	.....	984.44	1,932.94	427.50	.....	.....	427.50
December	932.50	11.10	704.05	1,647.65	435.00	47.81	.....	482.81
1892.								
January	832.49	.....	1.50	833.99	307.17	.....	.....	307.17
February	589.00	.....	.....	589.00	140.00	.....	10.60	150.60
March	446.00	120.68	54.56	621.24	204.00	.....	.....	204.00
April	491.00	.....	.....	491.00	214.84	33.70	.....	248.54
May	780.32	.....	.....	780.32	323.83	.....	.....	323.83
June	972.99	3.13	654.60	1,630.72	390.00	.....	496.15	886.15
Total	9,883.61	231.25	4,050.20	14,165.06	3,573.50	596.65	623.16	4,793.31

SUMMARY.

Lock No. 1, Kentucky River, Kentucky	$9,826.17
Lock No. 2, Kentucky River, Kentucky	2,884.08
Lock No. 3, Kentucky River, Kentucky	3,053.44
Lock No. 4, Kentucky River, Kentucky	4,148.11
Lock No. 5, Kentucky River, Kentucky	3,570.88
Lock No. 6, Kentucky River, Kentucky	1,712.72
United States snagboat *Kentucky* and steamer *Fulton*	14,165.06
United States dredges *Willie* and *Ward*	4,793.31
Lock-keeper's dwelling, Lock No. 2	1,446.10
Lock-keeper's dwelling, Lock No. 3	1,316.77
Lock-keeper's dwelling, Lock No. 5	978.17
Derrick boat	1,104.59
Grand total	48,999.40

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REPORT OF MR. R. S. BURNETT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Frankfort, Ky., June 30, 1892.

MAJOR: I respectfully submit the following report on the operating and care of canals and the maintaining and preserving of navigation on the Kentucky River, Kentucky, for the fiscal year ending June 30, 1892:

All work of repairs contained in the project for the fiscal year ending June 30, 1892, has been completed. The locks and dams are all in general good condition, with the exception of the dam at Lock No. 5, which leaks and requires backing. The arms in the upper gates at Locks Nos. 1 and 3 are so badly decayed that new gates are imperative for the safety of navigation.

The damage to the extension of the abutment below the dam at Lock No. 1 has not been repaired, on account of continuous high water in the Ohio River.

The city and county bridge at Frankfort, Ky., has not been raised.

The Louisville and Nashville Railroad Company have not raised their bridge at Frankfort, Ky., as required by act of Congress.

The following is a detailed statement of work done during the past fiscal year:

LOCK NO. 1.

Lock.—Removed five defective pieces of coping from lock walls and replaced with new stone; placed 14 square yards of cement, leveling scaled coping stone.

Dam.—Replaced sheathing on steps of dam that had been injured by drift. The comb of the dam was also repaired where drift had damaged it.

Abutment.—The crib extension of the abutment below the dam, which had been undermined by scour along its face, which caused the upper end to fall over into the river, has not been repaired on account of continuous high water in the Ohio River. No damage has occurred by reason of its not being rebuilt.

Upper shore guide wall.—Bank pressure forced the upper end of this wall 7 inches out of line at the top. The wall was strengthened by eight 1½-inch wire guy lines fastened to the face of the wall and anchored to deadmen placed 75 feet behind wall.

Quarrying stone at Gratz, Kentucky.—A quarry was opened at Gratz, Ky., the nearest available point on the river to Lock No. 1, for getting riprap stone required for making repairs to the extension of the abutment. One thousand nine hundred and forty-three cubic yards of riprap stone was quarried and 835 cubic yards of material was removed in stripping quarry.

General work.—The timber purchased for rebuilding the extension of the abutment was stacked immediately above the lock when it was found that it could not be used until next season; 579 pieces were taken out of the river and stacked, aggregating 177,256 feet B. M. Removing vegetation from Government land; recutting water-gauges; pointing lock walls; removing mud and drift from lock walls and from behind lock gates. Watching and caring for Government plant.

Dredging.—It was not found necessary to dredge lock entrances.

General remarks.—There was no suspension of navigation except for high water. The lock walls were submerged thirty days during the months of January, February, March, and April.

Highest water occurred April 26, upper gauge reading 41.60 feet, lower gauge 27 feet.

Lowest water occurred November 9, upper gauge reading 5.20 feet, lower gauge, 4.70 feet.

LOCK NO. 2.

Dam.—Replaced step sheathing knocked off by drift and respiked old sheathing.

Lock-keeper's dwelling.—Completed construction of lock-keeper's dwelling by hired labor and purchase of material by circular letter.

Dredging.—No dredging was required at either entrance to the lock.

General work.—Repaired and painted lock gates; recut and repainted water-gauges; removing drift and mud from lock entrances.

General remarks.—There was no suspension of navigation at this lock except for high water during the year. Lock walls were submerged by back water from the Ohio River and high rises in the Kentucky River eighteen days.

The highest water occurred April 22, lower gauge reading 41.50 feet, upper gauge reading 30 feet.

Lowest water occurred November 6, lower gauge reading 4.90 feet, upper gauge reading 6.40 feet.

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LOCK NO. 3.

Dam.—Replaced step sheathing knocked off by drift; respiked old sheathing; repaired upper slope and comb of dam.

Lock-keeper's dwelling.—Completed construction of lock-keeper's dwelling; laid 66 linear feet of brick pavement around dwelling; graded and sodded around dwelling.

Dredging.—No dredging was required at either lock entrance.

General work.—Tore down old lock-keeper's dwelling; repaired and repainted lock gates; repaired operating irons; whitewashed fence around premises; removed drift and mud from lock entrances and walls.

General remarks.—There was no suspension of navigation at this lock except for high water. The lock walls were submerged eleven days during the year.

The highest water occurred April 22, upper gauge reading 24 feet, lower gauge 33.30 feet.

The lowest water occurred November 5, lower gauge reading 5 feet, upper gauge reading 7.01 feet.

LOCK NO. 4.

Dam.—Removed from steps of dam 324 pieces of defective step sheathing and replaced same with new oak sheathing; repaired upper slope of dam.

Upper river guide wall.—Spiked 1,188 feet B. M. oak sheathing on face of wall.

General work.—Repaired and repainted lock gates and operating irons; removed drift ftom lock entrances and walls; repaired tool house; stopped leak in dam; repaired upper shore crib wall; built fence at lower end of premises; whitewashed fence.

Dredging.—Dredge *Ward* dredged 1,010 cubic yards of sand and mud from upper entrance and 25 logs; from the lock pit, 200 cubic yards, and from the lower entrance, 1,530 cubic yards of sand and mud.

General remarks.—There was no suspension of navigation at this lock except for high water during the year. The lock walls were submerged thirteen days.

The highest water occurred April 22, upper gauge reading 22.3 feet, lower gauge reading 35.8 feet.

The lowest water occurred October 17, upper gauge reading 4.8 feet, lower gauge reading 4.4 feet.

Dredging Lee Town bar.—This bar had shoaled so badly during the past year that it required dredging. The dredge *Ward* has dredged, in deepening and widening the channel, 3,500 cubic yards of earth, sand, and gravel, and removed same in dump scows.

LOCK NO. 5.

Dam.—To stop leak through the dam, 377 cubic yards of stone and clay and 20 cords of brush were placed behind as backing. Respiked old step sheathing; removed 8 defective pieces and replaced same with new oak sheathing.

Lock-keeper's dwelling.—Completed construction of new dwelling for lock-keeper; graded and built brick walks around dwelling; constructed 1 tool house.

General work.—Tore down old dwelling and utilized material in building walks and fencing Government land. Painted lock gates and assistant lock-keeper's dwelling; removed drift from lock entrance and lock walls.

General remarks.—Navigation was suspended fifteen days on account of high water and fourteen days on account of low water, caused by the construction of Lock No. 6 and leaks in the dam at Lock No. 5. The entire river was shut off from below Lock No. 6 for a period of twenty-eight days at the driest season of the year, when but little water was being voided from the upper river, the lower river being dependent upon small branches and springs to maintain the pool, while pool No. 6 was filling up. This will account for all the low gauge readings at all the locks.

The lowest gauge reading occurred October 15, upper gauge reading 0.10 foot, lower gauge reading 4.90 feet. The highest water occurred April 22, the upper gauge reading 22.60 feet, the lower gauge reading 33.50 feet.

LOCK NO. 6.

This lock was in operating condition for navigation November 21, 1891. For lack of funds the lower shore and river guide walls, as well as the upper river guide wall, were not constructed.

Filling behind the lock wall, grading and paving the bank, and constructing lock-keeper's dwelling were also omitted. A sufficient quantity of backing was not placed behind the dam.

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The lock has been successfully operated since the above-mentioned date, the lower entrance has shoaled up after rises in the river, and has required dredging from time to time.

The construction of the lower river guide wall will prevent, to a great extent, the shoaling of this entrance.

Dredging.—The dredge *Ward* dredged 6,840 cubic yards sand, clay, and gravel from lock pit and lower entrance.

General work.—Placed four check posts on inside lock wall; one check post on outside wall; placed four bolts in each end of lock wall.

UNITED STATES DERRICK BOAT.

Assisted lock keepers at Lock No. 6 in removing deposits of mud in upper lock entrance and removing stumps from lower entrance. Derrick was repaired by putting on two new stiff legs. Repaired roof of cabin.

DUMP SCOWS.

The two dump scows were taken to Madison, Ind.; hauled out upon the ways; new sheathing was placed on rakes, and scows calked.

UNITED STATES SNAG BOAT KENTUCKY.

The United States snag boat *Kentucky* has been engaged in towing dredges, barges, and scows to the several locks. Removed 38 snags during the year and ran 5,765 miles. Boat laid up one hundred and sixty days during year, sixty days of that time crew was on the steamer *L. A. Fulton.*

Respectfully submitted.

R. S. BURNETT,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

List of stern-wheel boats plying on the Lower Kentucky River, Kentucky.

Name of boat.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
United States snag boat Kentucky	Snag boat	136.6	30	4.6	330
Falls City	Packet	132.5	27	4.4	223.35
Bellaire	do	127.3	24.2	3.6	116.77
City of Clarksville	do	126	26	3.6	194
John Barrett	do	124.8	31	5.5	187.23
Henrietta	do	101.5	16.3	3.6	48.59
Isere	do	101.3	20.4	3.7	63.97
Rob Roy	do	100	19.4	3.7	70.93
Florence Shanks	do	96	16.5	3.8	26.42
Little Sandy	do	94	16	3	39.34
Ghent *	do	53	10	4	4.85
Florence *	do	48	11.5	4	4.08
Mazy	do	37	7.4	2.8	8.31
Favorite	do	109	15	3	43.64
Kate Prather	do				
Excel	Towboat	122	21.5	3.5	118.90
L. A. Fulton	do	122	22	3	107.99
Al Martin	do	112	23.6	4	96.88
Troubadour	do				
D. D. Baker	Saw mill	117	18.3	4.3	70.83
Sawyer	do	116	18	4.2	70

* Screw propeller.

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Report of lockages on Kentucky River, Kentucky, for fiscal year ending June 30, 1892.

Locks.	Days operated.	Days suspended.*	Going up.			Going down.				Total crafts and flats passing.	Total number lockages.
			Steamboats.	Barges and flats.	Miscellaneous.	Steamboats.	Barges and flats.	Rafts.	Miscellaneous.		
No. 1	336	30	439	153	64	453	182	223*	70	1,584	1,230
No. 2	348	18	426	150	94	438	134	195	125	1,562	1,339
No. 3	355	11	290	149	89	290	147	114	114	1,193	1,063
No. 4	353	13	301	157	160	302	149	209	155	1,433	1,236
No. 5	338	28	179	63	105	175	59	1,431	134	2,146	1,447
No. 6	223	.....	47	61	42	47	61	1,271	51	1,580	685
Total	.....	.....	1,682	733	554	1,705	732	3,443	649	9,498	6,999

*NOTE.—High water and filling Pool No. 6.

G G 6.

IMPROVEMENT OF LICKING RIVER, KENTUCKY, BETWEEN FARMERS AND WEST LIBERTY.

The project for the improvement of this river was approved by the Secretary of War under date of September 20, 1888, and provides for removal of snags, detached rocks, and bowlders, with a view to improving low-water navigation and rafting.

At the close of the last fiscal year a working party, which had commenced work at West Liberty, May 15, had reached Blackwater Creek, 28 miles below. During the balance of the season, which closed September 3, the work of improvement was carried to Farmers, and the most prominent obstructions removed or lessened in degree. The general plan each season has been to afford as much relief as possible in the way of general improvement of the river between Farmers and West Liberty, a distance of 68 miles, and the small appropriations have made it impossible to thoroughly complete the work in any locality.

During the fiscal year ending June 30, 1892, the following work was done:

Class of work.	Number.	Cubic yards.	Average length.	Average circumference.
			Feet.	*Feet.*
Solid rock removed	.....	2,001	.....	.....
Loose rock removed	.....	798	.....	.....
Snags removed	420	.....	22.8	5.2
Trees removed	183	.....	67.4	5.9
Stumps removed	303	.....	.....	.....

This river, under the present project, is not susceptible of permanent improvement, for the reason that such obstructions as snags, leaning trees, stumps, etc., are liable to occur after each high water.

The original estimate of the cost of this improvement was $17,680 for the 68 miles of river between Farmers and West Liberty, and it is recommended that of the balance yet unappropriated $5,000 be appropriated for the fiscal year ending June 30, 1894.

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APPROPRIATIONS.

August 11, 1888	$3,000
September 19, 1890	3,000
Total	6,000

Money statement.

July 1, 1891, balance unexpended	$2,034.67
June 30, 1892, amount expended during fiscal year	1,827.23
July 1, 1892, balance unexpended	207.44
Amount (estimated) required for completion of existing project	11,680.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Commerce of Licking River, Kentucky, fiscal year ending June 30, 1892.

Articles.	1890.	1891.	1892.
	Tons.	*Tons.*	*Tons.*
Bark	20		
Coal	912	190	1,900
Logs	33,750	20,000	30,000
Merchandise	100	12	13
Staves	19	70	175
Railroad ties			2,500
Total	34,801	20,272	34,588

G G 7.

IMPROVEMENT OF BIG SANDY RIVER, WEST VIRGINIA AND KENTUCKY.

The Big Sandy River, which is formed by the union of the Tug and Levisa forks, flows north a distance of 26 miles and empties into the Ohio at Catlettsburg, Ky. The main river and the Tug form the boundary between Kentucky and West Virginia, and the Upper Tug, for a distance of about 18 miles, forms the boundary between Virginia and West Virginia. The Tug Fork rises in the southwest corner of West Virginia and flows northwest to its junction with the Levisa Fork, with a total length of 140 miles. The Levisa Fork rises in the southwestern part of Virginia, then entering Kentucky, flows in a northerly direction. Its total length is about 189 miles.

The original project for improvement was adopted in 1878, and provided for the removal of obstructions from the Big Sandy and its two forks, in order to facilitate push-boat navigation and rafting. In 1880 this project was modified with a view to securing slack-water navigation by a system of locks and dams, and the first lock and dam were located at Louisa, Ky., just below the junction of the two forks, for the reason that the pools formed in the forks could be used for storage pur-

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poses during low water, and thus afford advantages for mining coal that no other location for a single lock could give.

At the close of the last fiscal year the lock was completed and equipped, a part—80 feet—of the permanent dam had been constructed, and the timber for the remainder had been contracted for and partly delivered. The abutment had already been built. The construction of a fixed dam was opposed by the timber and shipping interests, and under date of May 20, 1891, a Board of Engineer Officers was constituted "to consider and report upon the subject of the dam to be built in the Big Sandy River."

In its final report, the Board recommended the substitution of a needle dam in place of a fixed dam, the clear height of the pool formed by it to be 13 feet above the sill of the Navigable Pass.

As the length of the Navigable Pass should be sufficient to accommodate the commerce that may use it, and as the transportation of timber by rafting is the principal industry as yet developed on the river, the pass should evidently be long enough to pass rafts of the ordinary size, particularly as rafting is carried on at stages as low as 6 feet.

Considerations of economy with regard to construction and operation require that the pass should be as short as possible, consistent with the requirements of commerce. The circumstances of the case appear to require that the pass should be about 130 feet long.

In determining the elevation of the sill of the pass, the general principle that it, the sill, must not be an obstruction to navigation, should govern; in other words there must be as much depth on it, as boats can carry to it. This consideration would fix its elevation at least as low as the highest shoals.

When the lock was planned the elevation of its lower miter sill was fixed at 9 inches below the then accepted low water. Since then there are indications that the low-water surface at Louisa is higher than it was formerly. This is evidenced by the gauge readings in connection with the general condition of the river at the present lowest stages, and the fact that a part of the old steamboat landing at Louisa, which was formerly out of the water at lowest stages, is now and has been for a number of years, submerged at the lowest water. Push-boat navigation, which is effective with a draft of 9 inches, forms a fairly good practical standard of comparison for determining the relation between lowest stages of different years.

Granting that the reading of the lowest water is greater now than it was in former years, an explanation for it may be found, possibly, in the fact that since the commencement of the construction of the lock there has been a great change in the condition of affairs at and near the site of the lock, due to the partial obstruction of the natural waterway; but whether the change in low-water level will continue to exist as it now is, increase or diminish, can hardly be stated definitely, although the last would appear to be the most unlikely to occur.

Should there be no further change, it would be safe, taking into account the gauge readings during the low-water season, to place the sill of the pass one foot above the lower miter sill of the lock.

The needles forming the dam, pass, and weir, are to be supported by Poirée trestles, with an escapement which will allow the escape of all the needles between adjacent trestles at one time, thus doing away with the slow and laborious method of taking out each needle separately.

Plans and estimates of cost of the dam and its accessories will be submitted at an early date.

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APPROPRIATIONS.

June 18, 1878	$12,000
March 3, 1879	12,000
June 14, 1880	50,000
March 3, 1881	46,000
August 2, 1882	15,000
July 5, 1884	40,000
August 5, 1886	22,500
August 11, 1888	31,500
September 19, 1890	31,000
Total	260,000

Money statement.

July 1, 1891, balance unexpended	$29,734.15
June 30, 1892, amount expended during fiscal year	13,626.28
July 1, 1892, balance unexpended	16,107.87
July 1, 1892, outstanding liabilities	764.73
July 1, 1892, balance available	15,343.14
Amount appropriated by act approved July 13, 1892	50,000.00
Amount available for the fiscal year ending June 30, 1893	65,343.14
Amount (estimated) required for completion of existing project	28,029.25
Amount that can be profitably expended in fiscal year ending June 30, 1894	28,029.25

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. B. F. THOMAS, ASSISTANT ENGINEER.

LOUISA, KY., *June 30, 1892.*

MAJOR: At the close of the last fiscal year the work on Big Sandy River had been suspended until a decision could be reached in regard to the style of dam to be put in the river at this point. Owing to the necessity of waiting the low-water season to get such data as were required, the fall was too far advanced to begin operations at the date of the decision to construct a movable dam, even had it not been necessary to wait the action of Congress. It is expected now to begin work at an early day.

The contract for timber with Marting, Mittendorf, and Duis has been completed and the timber has all been repiled, so as to prevent, as far as possible, decay and warping. It is expected, now that it has been decided to put in a movable dam, to use this timber for cofferdams, for which purpose it is, generally, admirably adapted. Work upon the plans for the movable dam has been in progress for several months and designs for the entire substructure and the iron work have been submitted to you. Plans for the pass cofferdam have also been completed. In the computations and drawings, I have been assisted by Mr. J. M. G. Watt.

Owing to the great time the backwater from the Ohio River remains in the lower part of this stream, a great number of snags which have been released in the upper rivers settle into the sand and form obstructions to navigation. It is found necessary each year to remove these in order to render navigation safe. Last season a crew of thirteen men was put upon this work about the middle of November and remained out a little over a month. The work was under the charge of Mr. Fred McHenry, United States overseer. There were 205 snags, 54 trees, and 113 stumps taken out, and 120 cubic yards of rock blasted from points where it was an impediment to navigation. The places at which the principal obstructions were removed were: Fulkersons Bend, Branhams, Fullers, Rove Creek, Wrights Landing, Moores, Whites Creek, Savage Branch, and the C. & O. Bridge. The entire river, 26 miles in length, was placed in a splendid condition, but the rises of the winter and spring have brought in new snags, and it will be necessary to do some work this season, probably.

Respectfully submitted.

B. F. THOMAS,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

Commerce of Big Sandy River, West Virginia and Kentucky, for fiscal year ending June 30, 1892.

Articles.	1890.	1891.	1892.
	Tons.	*Tons.*	*Tons.*
Hides	75	50	40
Leather	34	30	4
Lumber	3,000	3,000	60
Produce	2,511	3,000	250
Live stock	495	500	150
Spokes	750	2,200	4,080
Staves	7,000	1,050	5,260
Tanbark	9,831	10,000	28,950
Timber, logs, and knots	208,491	225,000	300,050
Ties, railroad	15,000	10,000	99,625
Wheat	510	489	.....
Wool	11	15	7
Miscellaneous	19,000	21,069	16,050
Passengers	1,874	900	1,400
Total	268,582	277,303	455,926

List of boats plying on Big Sandy River, West Virginia and Kentucky.

Name.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
Frank Preston	Sternwheel	110	18	3	60
Sandy Valley	Sidewheel	105	14	2.8	40
Fairplay	do	125	19	3	49
Andy Hatcher	Sternwheel	117	18	3	65
Mary L. Hatcher *	do	110.4	20	3	55.05
J. C. Hopkins	Sidewheel	102.5	16.4	2.4	67
Beulah Brown	do	118	15	2.5	37.71
Sip Bayes	do	100	14	1.8	24.12
Ida Smith	Sternwheel	100	16	3	45
Virgie Ratcliff	Sidewheel	110	15	2.6	43
Favorite	do	103	14.8	2.5	43.64
Lexington	Sternwheel	120	22	3.5	48.72
Sea Lion (tow)	do	.....	.....	.....	.....
Gate City (tow)	do	.....	.....	.....	.....
Buckeye Boy (tow)	do	.....	.....	.....	.....
Tom Spurlock (tow)	do	117	22	3	100

* New line.

REPORTS ON DAM IN BIG SANDY RIVER, NEAR LOUISA, KENTUCKY.

[Printed in House Ex. Doc. No. 25, Fifty-second Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., November 20, 1891.

SIR: At the request of Hon. Thomas H. Paynter, M. C., and others interested in the navigation of the Big Sandy River, Kentucky, a Board of Officers of the Corps of Engineers was constituted by the Secretary of War to consider and report upon the subject of the dam to be built in the Big Sandy River, near Louisa, Ky., and I now have the honor to submit the accompanying copy of the report of the Board, dated November 10, 1891.

A dam of the fixed type had already been authorized and was under construction at this site when the interested parties requested that a movable dam be substituted for the fixed dam. The subject being reported on by the Board is in regard to the character of dam that should be built. It will be seen that the Board has given the subject full and careful consideration and is of the opinion that the best type of dam for the

site of Louisa is a movable dam of needles supported by trestles, and recommends the substitution of that type for the fixed dam now in course of construction. The estimated cost of constructing the movable dam proposed is $93,000, and, as there are only $17,000 on hand available for the fixed dam, a further appropriation of $76,000 will be necessary if the views of the Board are to be carried out.

I concur in the recommendations of the Board and recommend that the report be transmitted to the Speaker of the House of Representatives for the information of the Committee on Rivers and Harbors.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

REPORT OF BOARD OF OFFICERS OF THE CORPS OF ENGINEERS ON DAM IN BIG SANDY RIVER, NEAR LOUISA, KENTUCKY.

NOVEMBER 10, 1891.

GENERAL: The Board of Officers of the Corps of Engineers, constituted by Special Orders No. 31, from your office, May 20, 1891, "to consider and report upon the subject of the dam to be built in the Big Sandy River," near Louisa, Ky., have the honor to submit final report, as follows:

A dam had already been authorized, and was under construction, of the fixed type; and while this construction was going on the subject of the dam was referred to the Board because of a communication addressed to the Hon. John Sherman by Mr. E. Nigh, of Ironton, Ohio, dated May 2, 1891, and referred by the Senator to the Secretary of War. In Mr. Nigh's communication objection was made to the type of dam then under way and preference was expressed for a "wicket dam instead of the kind now being built," and a request was made "to have the matter investigated fully before proceeding with the work." This communication was referred for consideration and report by this Board, and thus the Board are to consider and report in regard to the kind of dam which should be built at the site in question.

In accordance with the terms of the order, the Board assembled at Louisa, Ky., on the afternoon of June 2, and on the next day at 10 a. m., in the court-house at Louisa, heard the statement of parties in interest, some in favor of abandoning the construction of the fixed dam, then under way, and substituting therefor a movable dam, and others in favor of carrying the construction of the fixed dam to completion.

The public meeting was quite large, composed of representatives from Cattletsburg, Louisa, and other towns on the river and its forks, as well as parties on the Ohio River having business relations with the river, and the interest shown in the subject before the Board was unusually great. Opportunity was given for very full discussion. Those speaking in favor of the movable dam were unanimous in expressing their preference for building no dam at all, unless the dam be movable, and expressed apprehensions as to the following points:

(1) The lock can not be operated rapidly enough to pass the rafts as they arrive, whereby delay will be caused, to the detriment of the rafting interests.

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(2) Because of the large quantities of sand moving, the pool will so fill

up as to be useless, and for the same reason the exit from the lock below will so fill in with sand as to prevent the passing of rafts even during a great part of the rafting stages.

Those opposed to the change of type desire the work to be carried on as at present authorized, because—

(1) The dam now under construction can be completed and made available at an earlier period than a dam of the changed type can be built.

(2) The system of fixed dams will cost less than a system of movable dams, and consequently the river will be sooner improved with the periodic appropriations made for the work.

The parties dissent from the parties opposed in regard to the apprehensions of serious evils inherent to the fixed type when applied to the Big Sandy River.

With this report, and returned with the original case, are a number of communications in which parties in interest have expressed views on both sides of the question at issue and to which attention is invited.

This first dam, while one in a series of similar structures, is specially intended, in advance of the construction of others in the series, to provide a pool for the harboring of loaded barges during low water. These boats can not get out of the pool during low water because of the lack of depth below the lock and out to the Ohio River. A rise from the upper river must then be awaited. The rises from the upper river bring large numbers of rafts, and it would then come about that the boats accumulated in this harboring pool and the arriving rafts would all be seeking passage through the lock during these periods of high water. To what extent this demand would tax the capacity of the lock in certain periods of time can not be determined from any data now at hand. To assume how many barges would be harbored in the pool at any one time would be mere guesswork. Information in regard to the number of rafts arriving per hour for any defined period is very indefinite. Attention is invited to the following tabular statement:

Timber output of Big Sandy River, 1882–'90.

Year.	Cubic feet.	Number of lockages of 8,000 cubic feet each.	Number of days river was at rafting stage at Louisa, Ky., 6 to 15 feet.	Remarks.
1882	5,524,000	690	.....	
1883	4,695,000	587	10	Record last half year only; no record for first half year.
1884	6,226,920	778	80	
1885	4,344,565	543	68	
1886	8,171,360	1,021	143	
1887	9,689,080	1,211	65	
1888	5,325,210	665	29	Record for first half year only; no record for last half year.
1889	4,555,000	569	182	
1890	*4,818,735	602	142	

* Given in reports as 107,083 tons, including cross ties.

The lock is large enough to take two rafts at one lockage, and it is believed that three lockages at least could be made in one hour. The most unfavorable year for the lock would have been 1887, when 1,211 lockages of rafts would have been required in sixty-five days, or less than twenty lockages per day. No other year for which the record is complete would have required as great an average as ten lockages per day during the rafting stages. There is no doubt that the lock could

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be operated more rapidly than would be needed to pass all rafts within the aggregate duration of the rafting stages for the year. But if rafts were rushed out within short intervals of time delay would necessarily ensue. As the barges accumulated in the pool would also, during these stages, be seeking passage through, delays both to rafts and boats would be increased.

The Board have not the data to permit them to give the probable limit of delay which would occur in actual practice. If the dam be movable no delay at all could occur in any event, and from that point of view the movable dam would be of advantage.

It is to be noted that the lumber business, as at present conducted, has no need for the facilities which will be provided by this dam, as the rafts are at once run out to the Ohio, and any delay caused by it will be without compensating advantages. The tabulated statement preceding shows that this trade, because of its extent, is deserving of consideration. It is said that certain interests desire to have logs stopped at Louisa that they may be there cut into lumber, thereby building up enterprises at that point; again, that other interests are opposed to this and desire the logs as now to continue to run out to Catlettsburg and the Ohio.

The coal trade, so far as transportation by river is concerned, is altogether undeveloped and must remain so until the stream is slack-watered.

As before stated, one of the objections urged against the fixed type of dam for the site near Louisa is, that it will arrest the movement of sand and the pool will fill with this material to the detriment of navigation. Considerable quantities of sand are brought down by the currents, but no measure of these quantities is available. The soundings taken during the investigations made for the Board in connection with measurements for discharge have shown the section of the river to be reduced as much as 150 square feet within a short interval of time. This filling was no doubt due to the progress of a sand wave downstream. The bars below Louisa and other indications evidence the movement of large quantities of sand. It is stated, and is no doubt a fact, that this movement has increased in these latter years.

The fixed dam being built, the sand moving down from above will at first be arrested at the upper end of the pool, decreasing the depth of water at that point. The increasing deposit will progress downstream, shortening the useful length of the pool for the harboring of boats and decreasing the navigable depth. There is no data available by which the rate of this deposit can be determined.

The dam being movable, it will be entirely closed only during the lowest stages, when the general movement of sand would be relatively very small. As the river rises the dam is progressively opened to afford passage for the increasing discharge without increasing the elevation of the pool at the site of the lock, and when the stage becomes such as to permit loaded boats to pass on downstream the dam is entirely open and then becomes, relatively to a fixed dam, little of an obstruction; in this respect decreasing according as the river rises to the higher stages. Necessarily, then, this arresting of the downstream movement of sand will be very much less for a movable dam than for a fixed one, and for the former type of dam will attain a maximum before the navigation and the availability of the pool for harboring boats are interfered with to the extent which would result from the construction of a fixed dam.

With a movable dam, navigation being through the dam and not through the lock at all the higher stages, as the river falls it may be

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easily determined whether there has been any deposit of sand to interfere with the passage through the lock. If such be found, the deposit can be removed and the lock put in perfect condition for use before the dam need be closed. Thus navigation will not be prevented for an instant.

The practical use of a movable dam, as indeed of any dam, involves a supply of water to cover the leakage through it when closed; otherwise the maintenance of the pool to its normal or even to a useful level will be impracticable. Measurements of the discharge of the river at stages varying from 16.2 feet on the gauge down to 1.98 feet on the gauge have been made, and a tabulation of these measurements is inclosed with this report. In a wicket dam the spaces between the wickets are 4 inches wide. Under the conditions at Louisa the discharge through one of these spaces at low water would be about 52⅙ cubic feet per second if the wickets were as high as at Dam No. 5, Great Kanawha River.

If we assume a weir with wickets 8 feet high, the discharge through one space would be about 24¼ cubic feet per second. If wickets be 4 feet from center to center throughout, this leakage through the spaces per foot of pass would be about 13 cubic feet, and per foot of weir would be about 6 cubic feet per second. Assuming for the Louisa dam 124 feet for the pass and 176 for the weir, their would be required about 2,680 cubic feet per second to supply this leakage; that is, an amount equal to the discharge of the stream at the guage reading of 5 feet, or somewhat over.

The spaces between the wickets, however, are covered at need by scantlings called joint covers, laid cornerwise upon them. An actual experience with a discharge measurement on the Great Kanawha River has given the following data: There are 62 wickets in the pass and 53 on the weir. Those in the pass are 13 feet vertical height from the sill to the top of the wicket, and inclined at an angle of 15½°; similarly those on the weir are 5 feet high, and inclined at an angle of 12°. The water below the dam stood 1.64 feet above the sill of the pass. The pool was maintained at fifteen-hundredths of a foot below the tops of the wickets. Under these conditions the discharge through each space between the wickets of the pass would be nearly 52 cubic feet per second, and through each space between the wickets on the weir about 12 cubic feet; that is, it would require 3,860 cubic feet per second to supply the leakage through these spaces of Dam 5. Joint covers had been placed over 60 of the spaces in the pass, and over 21 spaces on the weir. The discharge of the stream was measured below the dam and found to be about 1,130 cubic feet per second. This measurement was taken below the Elk River, and assuming the discharge of that tributary as low as 30 cubic feet, the balance of 1,100 cubic feet maintained the pool of Dam 5 to the level and under the conditions stated; that is, this partial covering reduced the amount necessary to maintain the pool to 30 per cent of that necessary to supply the discharge through all the spaces if uncovered. There were 2 spaces in the pass and 32 on the weir uncovered. The estimated discharge through these spaces was about 488 cubic feet per second, leaving 612 cubic feet as the leakage through the joint-covered portion of the dam, and between the wickets and the sills of that portion not joint covered. Omitting consideration for the time of the leakage under the wickets having no joint covers, the leakage through the joint-covered portion of the dam would be less than 1¾ cubic feet per foot of the aggregate length of the joint-covered portions of the pass and weir. But the leakage under the wickets is not to be neg-

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lected, so that the actual leakage per foot of the aggregate lengths of joint-covered wickets is still less than that given. Then, again, the leakage per foot of weir in any condition is much less than for the pass; consequently, if the weir were joint covered throughout, the average leakage per foot of joint-covered dam would on that account be still further reduced.

For the site of Louisa, where the aggregate length of the pass and weir would be, say, 300 feet, the data above noted permits us to assume with much assurance of correctness that the leakage through the dam, if of wickets and joint covered, would not much exceed 1½ cubic feet per second, and the pool yet remain with a useful available depth throughout, say a leakage of 500 cubic feet per second, equal to the discharge for the gauge reading of 2.8 feet. The water was below this stage for past years as follows:

Months.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
January	(*)	0	0	0	0	5	0	0	0
February	(*)	0	0	0	0	1	0	0	0
March	(*)	0	0	0	0	0	0	0	0
April	(*)	0	0	0	0	0	0	0	0
May	(*)	0	0	0	0	3	0	0	0
June	(*)	7	5	0	6	18	0	0	0
July	(*)	22	31	8	28	(*)	0	3	.....
August	21	22	19	6	30	(*)	1	0	.....
September	30	30	30	29	30	(*)	15	0	.....
October	26	31	29	31	31	(*)	0	1	.....
November	10	30	0	17	30	(*)	0	0	.....
December	20	14	0	0	27	(*)	0	0	.....
Totals	.....	156	114	91	182	.....	16	4	.....

* No reading.

It is believed that by means not difficult of application the leakage could be reduced to 1 cubic foot per foot of dam, say to 300 cubic feet per second, equal to the discharge for the gauge reading of 2½ feet, nearly. A lower stage than this obtained in past years as follows:

Months.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
January	(*)	0	0	0	0	2	0	0	0
February	(*)	0	0	0	0	1	0	0	0
March	(*)	0	0	0	0	0	0	0	0
April	(*)	0	0	0	0	0	0	0	0
May	(*)	0	0	0	0	3	0	0	0
June	(*)	3	2	0	3	17	0	0	0
July	(*)	20	29	7	26	(*)	0	0	.....
August	21	22	16	6	29	(*)	0	0	.....
September	30	30	30	28	30	(*)	10	0	.....
October	25	31	29	31	31	(*)	0	1	.....
November	8	30	0	17	30	(*)	0	0	.....
December	17	13	0	0	17	(*)	0	0	.....
Totals	.....	149	106	89	166	.....	10	1	.....

* No reading.

The estimated discharge through the spaces between needles in the aggregate is about one-fourth the estimated discharge through the spaces between the wickets for the same length of dam, or, for a dam near Louisa, say about 700 cubic feet per second. If the discharges through the needles be reduced by the application of additional cover even no more in proportion than the simple placing of joint covers has been found to decrease the discharge through Dam 5 of the Great Kanawha improvement, the lowest discharge so far measured for the Big

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Sandy will suffice to maintain the pool to a useful height. This additional cover, in the opinion of the Board, is easily feasible.

It is observed that the lowest gauge reading so far reached this year and for which measurement of discharge has been made is not so low as has been recorded in past years; the low water of 1883 was 1.23 feet lower. How much less the discharges were in the lower recorded stages of past years can not be ascertained or even estimated. There are indications that the bottom of the stream has filled somewhat with sand in these latter years, and a result of this filling would be that lesser discharge would correspond to higher gauge reading. So that, though the gauge reading has been as much lower as stated, it does not prove that the discharge has been correspondingly low. The tabulation of the gauge record indicates an obliteration of the lesser gauge readings as time progresses; such would actually result from filling of the bottom.

After full and careful consideration of all the elements determining a decision, the Board are of opinion that the best type of dam for the site at Louisa is a needle dam, and they recommend the substitution of that type for the fixed dam. It is further recommended that the height of the dam from the sill of the pass to the normal level of the pool be fixed at 13 feet, and that the dam be built across the river opposite the tail wall of the lock as is done in our practice, leaving all other details to be wrought out by the officer in charge.

The needle dam for the site near Louisa will cost somewhat less than a wicket dam.

In 1879 the recommendation was made by the officer in charge to build a fixed dam, with a view of ultimately turning the fixed dams into movable ones. Since that time experience has been had in this country with the operation and action of movable dams, and the Board are of opinion that the trial now made should be with that kind of dam.

With this report are inclosed a number of letters and papers addressed to the Board, and a list of them is also herewith.

Estimated cost of constructing a movable dam of needles, supported by trestles, Poirée system, on Big Sandy River, near Louisa, Ky.: Navigable pass, 125 feet; weir, 175 feet; vertical height of needles of pass, 13 feet; of weir, 8 feet.

PASS AND WEIR.

Fixed parts:	
Stone sill, 223.75 cubic yards, at $20	$4,475.00
Rear trestle stone, 102.5 cubic yards, at $16	1,640.00
Squared stone, 839 cubic yards, at $7	5,873.00
Paving stone, 315 cubic yards, at $10	3,150.00
Concrete stone, 2,688 cubic yards, at $7	18,816.00
Wrought-iron tie-rods, etc., 13,200 pounds, at 4 cents	528.00
Cast-iron anchors, 11,000 pounds, at 4 cents	440.00
Trestle journal-boxes, 17,625 pounds, at 7 cents	1,233.75
Bolts, nuts	300.00
	36,455.75
Pier and abutment:	
Coping, 79 cubic yards, at $16	1,264.00
Quarry face stone, 241 cubic yards, at $8	1,928.00
Squared stone, 341 cubic yards, at $7	2,387.00
Backing stone, 1,169 cubic yards, at $5.50	6,429.50
	12,008.50

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Movable parts:	
Pass, 125 feet, at $60	$7,500.00
Weir, 175 feet, at $40	7,000.00
	14,500.00
Excavation, 16,000 cubic yards, at 50 cents	8,000.00
Cofferdam	15,000.00
	23,000.00
Cost of foundation, pass and weir	36,455.75
Cost of abutment and pier	12,008.50
Cost of movable parts above foundation	14,500.00
	85,964.25
Taking down old abutment, 1,100 cubic yards, at $1	1,100.00
New upper gates	3,000.00
Excavating upper approach, 10,000 cubic yards, at $1	10,000.00
Cutting down upper miter and headwall 6 feet, 386 cubic yards, at $2.50	965.00
Paving bank about abutment	3,000.00
	104,029.25
Deduct value of 2,000 cubic yards stone in present abutment and in yard, at $5.50	11,000.00
	93,029.25

The cause of the delay in sending this report has been the necessity of obtaining certain information as to the discharge of the river at low stages, and this could only be had by waiting for the river to fall. A tabulation of the discharge measurements is herewith.

WM. P. CRAIGHILL,
Colonel, Corps of Engineers.
D. W. LOCKWOOD,
Major of Engineers.
THOMAS TURTLE,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

G G 8.

IMPROVEMENT OF LEVISA FORK OF BIG SANDY RIVER, KENTUCKY.

The Levisa is the western of the two forks that unite at Louisa to form the Big Sandy River. It rises in the southwestern part of Virginia, at an elevation of about 1,500 feet above tide water, and flows in a northerly direction. Its banks in many cases are rocky, in others composed of sand and clay. It possesses all the characteristics of a mountain stream, a steep average slope, and pools of varying depth, separated by rock bar or ripples that at low water often have but a few inches of water over them. The average fall from Pikeville to Louisa is 1.49 feet per mile, the distance being 86½ miles.

The object of the improvement has been to facilitate rafting and push-boat navigation in the upper river and to improve low-water steamboat navigation so far as this can be done. Steamboats can not run in this or Tug Fork at dead low water, but the work done so far has been of such a character as to permit of their running on smaller rises than was the case before the improvement was commenced.

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Coal mines have been opened at and near Peach Orchard, and quite extensive shipments are made by rail to Ashland, on the Ohio, where it is put in barges for transportation down that river. Could coal be shipped out by water from the mines the output of coal would be largely increased.

As work on this stream can only be done to advantage during low water, it was September 10, when the working parties were sent out.

The work of previous years has removed the most important obstructions, so that during the past season it was only necessary to clear out chutes that had become obstructed by material washed in during the preceding high waters, and take out such obstructions as logs, stumps and snags that are always found in the channel after a rise.

The following is a summary of the season's work:

Work.	Cubic yards.	Number.	Average length.
Solid rock removed	320	.....	.....
Loose rock removed	1,310	.....	.....
Snags removed	.....	390	25.7
Trees removed	.....	150	69.3
Stumps removed	.....	276	.....
Trees topped	.....	9	.....

The stream under the present project is incapable of permanent improvement, as the obstructions to navigation, such as snags, stumps, logs, etc., are liable to re-form at any time and an annual appropriation of about $2,500 is needed to keep it clear.

APPROPRIATIONS.

June 14, 1880	$2,500
March 3, 1881	2,000
August 2, 1882	5,000
July 5, 1885	5,000
August 5, 1886	3,750
September 19, 1890	2,500
Total	20,750

Money statement.

July 1, 1891, balance unexpended	$1,151.76
June 30, 1892, amount expended during fiscal year	1,131.90
July 1, 1892, balance unexpended	19.86
Amount appropriated by act approved July 13, 1892	2,500.00
Amount available for fiscal year ending June 30, 1893	2,519.86
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	2,500.00

G G 9.

IMPROVEMENT OF TUG FORK OF BIG SANDY RIVER, WEST VIRGINIA AND KENTUCKY.

The Tug Fork is the eastern of the two forks which unite at the town of Louisa, 26 miles from the Ohio, to form the Big Sandy River. It rises in the southwest corner of West Virginia and flows towards the

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northwest for a distance of 140 miles. For a distance of 18 miles at its head it forms a part of the boundary between Virginia and West Virginia, and below this it and the Big Sandy form the boundary between West Virginia and Kentucky.

The Tug throughout most of its length is a characteristic mountain stream formed of a series of pools separated by ripples.

The average fall per mile from Pond to Warfield, a distance of 23.5 miles, is 1.96 feet per mile, and from Warfield to Louisa, a distance of 35 miles, 1.72 feet per mile.

The object of the improvement has been to facilitate rafting of logs from the upper portion of the stream and its branches, to provide a low-water push-boat channel, and to make it possible for light-draft steamboats to run at lower stages than formerly while the river was in an unimproved state.

The work done has been that of clearing the channel of rocks, snags, stumps, etc., and the banks of overhanging trees, while with special reference to the push-boat interests, channels have been cut through the ripples or shoals.

The Government has improved this river from its mouth, at Louisa, to Baileys Dam, a distance of 100 miles.

As the roads through the mountains are little more than trails, they are entirely unfitted for freighting purposes, so that the people along the river, and particularly those well up the stream, are almost entirely dependent upon water transportation for obtaining supplies, etc. The lower portions of the river are reached by steamboats, but above steamboat navigation push-boats alone can be used, and little channels have been made through the shoals and ripples in the past for their passage. This kind of navigation may appear to be of comparatively little account, but gains in importance materially when it is considered that it furnishes the only means of communication for obtaining supplies.

Again, the Tug being a small stream of steep slope with rocky banks in many places, it is dangerous to run rafts in high rises, owing to the difficulties of management due to sharp bends and swift currents, consequently timber is brought out only on moderate rises and preferably on a falling river.

The Norfolk and Western Railroad follows the right bank of the Tug Fork for some distance, and its construction has to a greater or less degree affected the navigable capacity of 22 miles of the river from the upper limit of the improved portion down. The road in some places follows the bank closely, and large quantities of rock have been blasted into the stream in grading the road bed, while stumps and trees have been rolled into the river with no regard to their effect on navigation. In one place a rock dam 10 or 12 feet high extends across the river, which effectually closes it for rafts coming from above. It is safe to say that the work of the United States in the upper 22 miles of improved river has been practically destroyed.

Under date of July 1, 1891, the Norfolk and Western Railroad *et al.* were perpetually enjoined from obstructing the navigation of the Tug Fork, and ordered to remove obstructions already created by them before the 15th day of November, 1891, and furthermore, they were permitted to go forward with the construction of the road, and if any rocks, trees, etc., were accidentally or from necessity thrown into the stream, they were to be removed within three months, and finally, all said rock, stone, trees, logs, lumber, timber, and débris were to be removed before November 15, 1892. A bond of $25,000 was required for faithful compliance with the decree.

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There has been no change in the situation so far as I can determine, except that the obstructions have been increased.

This stream is incapable of permanent improvement, as the obstructions formed by logs, snags, etc., are liable to re-form at any time, and a small annual appropriation is needed to keep it free.

The following is a summary of work done during the past fiscal year:

Solid rock removed	cubic yards.	80
Loose rock removed	do	2,147
Snags removed	number	392
Trees removed	do	392
Stumps removed	do	350
Trees topped	do	192

APPROPRIATIONS.

June 14, 1880	$2,500
March 3, 1881	2,000
August 2, 1882	5,000
July 5, 1884	5,000
August 5, 1886	3,750
September 19, 1890	2,500
Total	20,750

Money statement.

July 1, 1891, balance unexpended	$1,421.67
June 30, 1892, amount expended during fiscal year	1,270.33
July 1, 1892, balance unexpended	151.34
July 1, 1892, outstanding liabilities	40.55
July 1, 1892, balance available	110.79
Amount appropriated by act approved July 13, 1892	2,500.00
Amount available for fiscal year ending June 30, 1893	2,610.79
Amount that can be profitably expended in fiscal year ending June 30, 1894, Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	2,500.00

G G 10.

IMPROVEMENT OF GUYANDOTTE RIVER, WEST VIRGINIA.

The Guyandotte River rises in the southwestern part of West Virginia, and, flowing in a northwesterly direction, empties into the Ohio 12 miles above the mouth of the Big Sandy and 39 miles below the mouth of the Great Kanawha.

The project for the improvement was adopted in 1878, and contemplated the obtaining of a clear channel with a width of 30 feet and a least depth of 18 inches during five months of the year by the removal of rocks, snags, and other obstructions. This river was practically closed before work commenced, except during rises of considerable height.

The stream was once improved by the State of Virginia by the construction of six locks and dams. The locks were constructed of timber, and, as a matter of course, after a time, the charges for repairs, ren-

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dered necessary by the natural decay of the wood, became very great, and a little further along the system was abandoned, and what had formerly constituted a useful improvement now became obstructions. The old locks and dams were carried away in part from time to time by floods, so that when the first report on this river was made by Maj. William E. Merrill in 1875 most of them had been partially washed away, but the ruins of one still constituted the worst obstruction on the river.

There are two milldams—Pecks, 7 miles below Logan, and Lamberts, 19 miles below Pecks—that still constitute serious obstructions to navigation, and have been reported to the Department as such. The authority for their construction in the first place was based upon a permit from the circuit court, and their continuance has been a nuisance and constant damage to the river interests.

The work in previous years has been to cut passage ways through the old dams where required, make channels through the shoals for push boats, and remove such obstructions as rocks, snags, stumps, logs, etc., existing in the channel, of the river as would interfere with rafting at ordinary and low rafting stages. During the past year the work done has been with a view to assisting the running of rafts. The stream is incapable of permanent improvement, as the obstructions in the channel, such as trees, snags, logs, etc., are liable to re-form. The stream up to Logan, a distance of 81½ miles, has an average fall of about 22 inches to the mile.

For details concerning the work attention is invited to the report of Assistant Engineer B. F. Thomas, attached hereto.

APPROPRIATIONS.

June 18, 1878	$2,000	July 5, 1884 *	$2,000
March 3, 1879	1,000	August 11, 1888	2,000
June 14, 1880	2,000	September 19, 1890	2,000
March 3, 1881	3,500		
August 2, 1882	2,000	Total	16,500

Money statement.

July 1, 1891, balance unexpended	$1,397.00
June 30, 1892, amount expended during fiscal year	1,303.30
July 1, 1892, balance unexpended	93.70
July 1, 1892, outstanding liabilities	.25
July 1, 1892, balance available	93.45
Amount appropriated by act approved July 13, 1892	2,000.00
Amount available for fiscal year ending June 30, 1893	2,093.45
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections of river and harbor acts of 1866 and 1867.	2,000.00

REPORT OF MR. B. F. THOMAS, ASSISTANT ENGINEER.

LOUISA, KY., *June 30, 1892.*

MAJOR: At the close of the last fiscal year a force was at work on Guyandotte River at Big Huff Creek widening the chute at that point. About 1,600 cubic yards of rock were removed during the first half of July, when the party began the descent of

* Made available by act of August 5, 1886.

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the river, working as they went. At Fish Trap Shoal a large rock was taken out; also a tree which was in the chute. The point of the bar was cut off and a slip on the left bank was removed. At Neiberts Bend, 7 miles above Logan, a portion of the point of Cloyds Island and a heavy rock slip on the east side of the river were removed, forming a most useful and excellent piece of work. The point of a rocky bar was cut off at Lawsons Mill, where the river makes a short bend. A large tree was taken out of the main channel at Logan and three more near King Shoal. Three rocks were removed at Dry Island and also three at King. Some rocks were removed about 5 miles below Big Hart Creek. A great many trees, stumps, snags, etc., were removed all along the river from Kings Shoal to Rogers Dam, a distance of 62 miles. At Barboursville a very bad piece of river was found and considerable work was done there, but the appropriation was exhausted without completing the improvement. There is a rocky island and also a rock bar that ought to be removed, as they lie in a bend of the river and at certain stages of water are a great and dangerous obstruction. A detailed statement of work done is below:

Solid rock removed	cubic yards	424
Loose rock removed	do	4,280
Snags removed		15
Trees removed		32
Drifts removed		7
Saw logs removed		300
Traveled with boats	miles	172½
Men employed (average)		10

The improvements made by the United States on this stream have been of great benefit to the people of that section, and it is estimated that the output of timber has greatly increased this year. A small steamboat now plies the river, and if the Government would remove the dams in the lower part of the streams there is nothing to hinder steam navigation to within 7 miles of Logan, or a distance of 73 miles. Of course there are other obstructions in the bed of the river and overhanging timber which must be removed before navigation can be an entire success, but the principal work to be done is to secure the removal of the dams heretofore reported as obstructions to navigation. I think that further appropriation for the Guyandotte River should be made for that purpose solely until the removal of all dams is effected. R. H. Gamble conducted the work.

Respectfully submitted.

B. F. THOMAS,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Cincinnati, Ohio.

COMMERCIAL STATISTICS.

Commerce of Guyandotte River, West Virginia, for the fiscal year ending June 30, 1892.

Articles.	1891.	1892.
	Tons.	*Tons.*
Cross-ties	.....	12,500
Timber	60,000	90,000
Miscellaneous	1,128	1,300
Total	61,128	103,800

List of boats plying on Guyandotte River, West Virginia.

Name.	Character.	Length.	Breadth.	Depth.	Tonnage.
		Feet.	*Feet.*	*Feet.*	
Ed. C. Kirker (tow)	Side wheel	73	8	2	7

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G G 11.

IMPROVEMENT OF LITTLE KANAWHA RIVER, WEST VIRGINIA.

The Little Kanawha drains the central portion of West Virginia, rising in Upshur County; its course is a little north of west and it empties into the Ohio at Parkersburg; its total length is about 150 miles.

The Little Kanawha Navigation Company owns and operates four locks and dams on this river, which furnish slack-water navigation from the Ohio up to a point two miles above the village of Burning Springs, where the United States lock is located, but the service of this system is very poor, owing to the dilapitated condition of both locks and dams; breaks and washouts are of frequent occurrence during high water, and the interruption to navigation in consequence expensive and harassing.

The present project for the improvement of this river, adopted in 1876 and modified in 1880, contemplates the construction of a lock and dam to extend slack-water navigation for a draft of 4 feet a distance of 12 miles above the point reached by the navigation company, and the improvement of the natural channel of the upper river by the removal of obstructions, etc., for a distance of 80 miles, the object of the latter being to obtain a channel of a minimum width of 40 feet with a depth of 2 feet for at least four months in each year.

During the past fiscal year the lock and dam were completed to such an extent that the lock was opened to navigation December 2, 1891. It was found impossible to complete the backing of the dam before the winter set in, and this work was deferred until after the spring floods. The backing of the dam is now in progress and will be completed in a short time. As always happens where proper bank protection is not put in in advance, the banks just below the lock and abutment have washed considerably, but not to a dangerous extent. The completion of the lower shore guide wall and placing of riprap below the abutment will effectually secure the banks against further washing.

For details of work done during the past year attention is invited to the report of Assistant Engineer B. F. Thomas, appended hereto.

APPROPRIATIONS.

August 14, 1876,	$7,300	August 5, 1886	$16,875
June 18, 1878	18,000	August 11, 1888	25,000
March 3, 1879	18,000	September 19, 1890	40,000
June 14, 1880	15,000		
March 3, 1881	40,000	Total	211,175
August 2, 1882	31,000		

Money statement.

July 1, 1891, balance unexpended	$27,315.29
June 30, 1892, amount expended during fiscal year	23,805.89
July 1, 1892, balance unexpended	3,509.40
July 1, 1892, outstanding liabilities	986.05
July 1, 1892, balance available	2,523.35

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REPORT OF MR. B. F. THOMAS, ASSISTANT ENGINEER.

LOUISA, KY., *June 30, 1892.*

MAJOR: At the time of my last report upon the work being done upon the Little Kanawha River the dam had just been started, the space between the lock and river bank had been filled, and the masonry of the abutment had been finished.

In the early part of the present year the continued wet weather prevented much being done. Another drawback, and one which was more serious than rain, was that we could not get a dredge. The trouble was caused largely by the inability to find one small enough to go through the locks of the Little Kanawha Navigation Company. Finally, after long delay, the dredge *Willie* arrived upon the work from Kentucky River on the 8th of September, and did most excellent service throughout the season. Before the arrival of the dredge, and when it was believed that none would come, preparations were made for building the dam by using a coffer, and considerable work was done upon the coffer with that in view. The coffer was originally intended to become a part of the dam, and this plan was carried out on the part constructed.

The work done by the dredge consisted of the excavation of 4,500 cubic yards from the site of the dam; 2,700 cubic yards next the river wall of lock, when it was necessary to put in a protection crib; 13,000 cubic yards from the lower approach to lock, and 1,000 cubic yards from the site of the protection crib at lower end of lock. Much of this material was loaded on barges and boated to deep water, where it was shoveled off. In addition to this work, the dredge removed the old lock coffer, pulling all the piles and sheet piling and all the logs and drift which had collected and been buried inside this inclosure. A great many trees and logs were also removed from the lower lock approach. The material was generally a tough clay, with an occasional seam of gravel and many large bowlders.

Construction of dam.—The first crib of the dam, 100 feet long, was sunk to rock and brought up above ordinary water last year. The next crib is 65 feet long and the last one 85 feet long. These were constructed in place and sunk to rock, when they were filled with broken stone and anchored to the bed rock with heavy bolts. All the cribs having been brought up above water were then connected with long timbers and well bolted together, forming, as it were, one solid crib from abutment to lock wall. This was covered with 9-inch decking laid parallel with the thread of the stream. Each step is about 10 feet wide and 3 feet 3 inches high. The dam is 50 feet wide and its crest is 10 feet downstream from its upper face. The lift is 12 feet. The timber of which the dam is made is white oak and other hard wood and is 10 by 10 inches in size generally. The ties and stringers cross each other at about 10 feet intervals and are drift-bolted together.

Protection cribs and other crib work.—A crib reaching from the dam the entire length of the lock wall was put in alongside the river wall of lock and filled with stone and decked over. It is for the purpose of protecting the lock foundations, which are concrete set on a soapstone and gravel bed. Its crest is slightly above pool level.

A crib for the convenience of craft entering the lock, as well as for the protection of the bank above the lock, was built and filled with stone adjoining the upper end of land wall. It is 100 feet long and about 18 feet high. The bank behind it was only partially graded and filled in with earth.

Above the river wall on the outside of the upper lock approach, a small guide crib was put in and filled with stone. It reaches to about the level of the lock coping.

Beginning at the lower end of land wall and extending downstream 100 feet, a crib for the protection of the river bank was put in. Its lower end has a return or wing extending into river bank to prevent the return current from cutting behind it. This crib was carried up within 9 feet of the top of the lock and preparations are now being made to bring it to the full height. The construction of a crib leading from the wing wall of the abutment into the solid bank was found necessary in order to prevent the earth from being cut away. This crib was filled with stone and sheathed on the upper and lower faces. A heavy earth fill was put in above it and broken stone placed below it.

At the quarry, one-half mile below the lock, an inclined track reaches from the ledge of stone down to the river and is carried out over the water so as to bring the cars carrying the stone immediately over the barges for loading. The outer end of this track is supported on a crib. Owing to the exposed location of this crib, it was necessary to rebuild it after every high freshet and replace the track which was generally carried away by the drift of logs catching against it.

Lock gates and wickets, ladders and needle dam.—The lock gates, which were about framed at the time of my last report, were put in place and painted early in the year. The moving apparatus at first put in was found to be too light for the great amount of work to be done and was returned to the shop and new capstans were made and the rack bars were strengthened. The new capstans were placed farther from the face of the wall and have since worked with great satisfaction under all

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conditions. The lower gates were found to leak by not coming entirely against the sill at the toe, but as the waste in no way interfered with navigation it was deemed best to defer the stopping of the leak until warm weather, and in consequence nothing was done with it until the present month, when it was closed.

The wickets were put in position and the crabs for maneuvering them were placed. Coping stone was cut and fitted around the moving apparatus. Screens for the protection of wickets were placed on face of wall over wicket opening. A recess was cut in each lock wall and an iron ladder was placed therein. These ladders have been found of great utility and convenience. The trestles, together with the wooden sills for the needle dam at head of lock, were put in. This dam is intended for use as a coffer when it is found necessary to make repairs to the upper gates or wickets.

Lock floor, paving, quarrying, etc.—The earth was removed from between the lock walls and a bed of concrete was put in place to form a floor for the lock. One hundred and fifty-three cubic yards of concrete were placed. On top of this concrete a timber floor was built in the upstream end of the chamber to receive the swift water from the upper wickets.

Paving stone was quarried and over half the space behind the lock was paved. It is the intention to complete the paving next month, as the cold weather prevented its completion last season. On account of building the protection cribs it was found necessary to again open the quarry. This was done in September, and about 2,000 cubic yards were gotten out and most of it used in filling the cribs. The quarry is located high on the hillside and the stone is transported in cars down an inclined track and dumped on barges and pushed to the works. At the start the loaded car was used to haul an empty one back to the quarry, but owing to the numerous changes of grade (the track having been built on the ground without grading) it was found advantageous to use an engine for hauling up the empties. This engine and a boiler for furnishing steam were placed at the top of the incline. A water car was added to the plant and everything worked very well. Now that a pool has been formed above the lock, it has been found best to obtain stone from a quarry located about two miles above the one used last season.

General work.—In order to work on the lower lock gates without pumping the entire lock chamber a temporary cofferdam was thrown across the lock just above the gate recess. This was removed when it was no longer of use. When putting in lock floor it was necessary to boat sand from a point about half a mile below lock. At the same time a large quantity of mud was removed from the lock chamber and the pump was kept running day and night. The cement for the concrete was taken up from the river and stored in a shed built for the purpose.

While pumping and otherwise using steam, slabs from an adjacent sawmill were hauled and cut up for fuel. Some coal was also used and this had to be wheeled from river to boiler house. The boilers were repaired during the season, causing a delay of several days with the work. While the lock was pumped out the walls were pointed, except in a few places, which has been done lately. The upper approach to lock and site of upper protection crib was excavated by men and tools, as the dredge could not then be spared from other work. The material thus removed was used for backing the dam. This, together with a few barge loads of broken stone from the quarry, was all the backing put in last season. During the present month the work of backing the dam has been resumed by dredging out the material in the lower lock approach and that adjoining it and boating the same through the lock. On top of this material, which is a gravelly clay, will be placed a good layer of broken stone.

The summer and fall freshets caused considerable extra work last season on account of carrying away timber and tearing up crib work. One of the dam cribs was thrown out of position by the swift water, and it was found necessary to take it apart and make a raft of it in order to return it to the dam site. This was a difficult operation, owing to the insufficient means at hand for pulling drift bolts. These freshets also carried logs into unfinished work and against the quarry track, which had to be removed, sometimes at great expense.

When building the dam, a chute was used for putting the timber in river. This chute led from the timber pile down the bank into the water. This was carried away and had to be replaced. Considerable timber was lost in the floods, but generally it was caught within a few miles of the lock and returned.

Before laying the paving behind lock wall, the banks were graded with teams and scrapers. Some earth was also filled in behind the guide or protection cribs in the same manner. A levee or dike of earth was built from a point opposite the upper gates back to the solid bank behind lock in order to force the water at a high stage to pour over the upper gates instead of spreading out over the paving.

The overhanging timber at approaches to lock was cut and removed, and as the action of the water has carried the banks away below the lock it has been found necessary to cut some trees that were left last season.

In putting in the lower protection crib, the sliding banks gave much trouble.

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Considerable inconvenience and expense as well as delay was caused by the drawing of the pool to repair the Palestine Lock, belonging to the Little Kanawha Navigation Company. This so reduced the water that but small loads of stone could be boated, and even these had to be tied up some distance below when needed and the stone wheeled in barrows to its destination. At times the length of wheeling was 500 feet. It was very tiring to men as well as expensive and slow.

During this year the contract for timber for dam was filled, and timber for the cribs was also purchased. T. W. Moore, the contractor, furnished 417,686 board measure feet of timber. Smith & Co. also furnished some timber for protection cribs. The lock irons were furnished by Pattin, Hall & Pattin, of Marietta, Ohio.

Respectfully submitted.

B. F. THOMAS,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Commerce of Little Kanawha River, West Virginia, for fiscal year ending June 30, 1892,

Articles.	1890.	1891.	1892.
	Tons.	*Tons.*	*Tons.*
Coal	1,100	10,507	3,100
Lumber	8,540	28,677	20,486
Oil	678	1,450	1,738
Staves	24,500	26,964	10,050
Timber	70,000	59,703	109,337
Ties, railroad	27,650	48,312	92,200
Passengers	1,563	1,500	1,343
Miscellaneous	6,084	13,575	6,000
Total	140,115	190,688	244,254

List of boats plying on Little Kanawha River, West Virginia.

[Character, stern-wheel.]

Name.	Length.	Breadth.	Depth.	Tonnage.
	Feet.	*Feet.*	*Feet.*	
Oneida (packet)	104	19.5	4.2	75.78
W. A. Hilton (packet)	105	22	3.6	67.54
D. T. Watson (tow)	99	17	2.6	80.45
J. King (tow)	66.5	.....	3	34.93
Mary E (tow)	86	13.6	.....	.....
Lulu F (tow)	98.4	15.1	2.6	37.16

G G 12.

OPERATING AND KEEPING IN REPAIR THE LOCK AND DAM ON LITTLE KANAWHA RIVER, WEST VIRGINIA.

Lock and Dam No. 5 of the Little Kanawha River were so far advanced towards ultimate completion that the lock was opened to navigation December 2, 1891, and has since that time been continuously operated, with the exception of a short time during June, when it was closed to readjust the lower gates to the miter sill and put new screens in the chamber openings of the lower culverts.

Considerable damage was done to the dam during the winter by loose logs and ties going over it and pounding off the sheeting of the lower step, but as the companies or firms engaged in running logs in

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this manner have put in booms above the lock, it is hoped that there will be no trouble from this source in the future.

Allotment for year ending June 30, 1892, $1,500.

Detailed statement of expenses incurred in preserving and maintaining navigation on that portion of the Little Kanawha River, West Virginia, improved by lock and dam during the fiscal year ending June 30, 1892.

Months.	Salaries.	Labor and material.	Current and contingent expenses.	Total.
1891.				
December	$95.00			$95.00
1892.				
January	95.00		$14.25	109.25
February	95.00	$21.25	3.65	119.90
March	95.00		1.25	96.25
April	95.00		1.25	96.25
May	95.00			95.00
June	95.00			95.00
Total	665.00	21.25	20.40	706.65

REPORT OF MR. B. F. THOMAS, ASSISTANT ENGINEER.

LOUISA, KY., *June 30, 1892.*

MAJOR: Locking was begun on the Little Kanawha River, at Lock No. 5, on December 2 last, and nothing has occurred to interfere with navigation since then except a short stoppage to repair a leak between the lower gates and miter sill during the present month. The lock has been in fine working condition ever since it was opened to navigation. While the approaches to the lock were being made ready after the completion of the dam, some of the timber firms operating on the river became fearful that navigation through the lock would not be opened speedily and made no preparations for holding their timber in the upper pool, but allowed it to escape over the dam. This was continued for several weeks after navigation was established and assured, and the dam was greatly injured by the loose logs and cross-ties pounding the decking or floor. The lower step of the dam has been partly carried away and nearly all loosened, and the entire lower face of the work has been damaged more or less. For the past two or three months but few logs have gone over the dam, and the lockage of rafts has greatly increased in consequence. The construction of this dam has lengthened the navigable river about 12 miles, and boats run regularly to Creston at the mouth of the West Fork. This is of great benefit, not only to people living in the vicinity of the pool, but also to those occupying the upper part of the valley, as it brings the head of navigation much nearer to them.

The intention originally was to employ but one lock tender, as is done on the locks below owned by the Little Kanawha Navigation Company, and with this idea but one lock house was built. The greatly increased business of the river, particularly in timber and cross-ties, which is always greatest at the upper lock, made it necessary to employ an additional lock tender, and it will be to the interest of the United States to erect another dwelling this season for his use.

No damage of consequence has resulted to the lock. Two wicket screens were torn off during the high water of the winter and spring, but caused neither inconvenience nor delay to navigation.

The river bank below the abutment has washed away considerably, and it would be best to protect it with riprap before another winter. Below the lock there has been some erosion of the land, but it has not yet progressed far enough to cause uneasiness, and the probabilities are that it will stop without damage to the work or adjacent property.

Respectfully submitted.

B. F. THOMAS,
Assistant Engineer.

Maj. D. W. LOCKWOOD,
Corps of Engineers, U. S. A.

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*Report of lockages on Little Kanawha River, West Virginia, for fiscal year ending June 30, 1892.**

Lock No. 5:	
Days operated	197
Days suspended	13
Going up:	
Steamboats	259
Barges and flats	168
Miscellaneous	61
Going down:	
Steamboats	361
Barges and flats	146
Rafts	1,915
Miscellaneous	52
Total crafts and flats passing	2,913
Total number of lockages	2,871

G G 13.

IMPROVEMENT OF BUCKHANNON RIVER, WEST VIRGINIA.

The project for the improvement of this stream, approved in 1884, is to clear out that portion of the river between the Three Forks and the town of Buckhannon, a distance of 24½ miles. The obstructions consist of log jams and bowlders, some of which are estimated to contain 500 cubic yards.

The project called for a channel 30 feet wide.

Buckhannon River is a tributary of the Tygart Valley, and rising in the southwestern part of Randolph County, W. Va., flows a little east of north until it empties in the Tygart Valley River in Barbour County.

The distance from the Three Forks to the mouth is 47½ miles, and the total length of the stream is about 57 miles.

During the past fiscal year work was commenced during the last week of August, and continued so long as the balance of funds available would warrant.

Forty-five large bowlders were removed, containing in all 3,510 cubic yards of stone, and 136 trees and 25 logs were taken from drifts and jams.

No additional appropriation is required for this work.

APPROPRIATIONS.

July 5, 1884	$1,500.00
August 5, 1886	1,500.00
August 11, 1888	1,500.00
September 19, 1890	1,000.00
Total	5,500.00

Money statement.

July 1, 1891, balance unexpended	$1,027.40
June 30, 1892, amount expended during fiscal year	1,010.18
July 1, 1892, balance unexpended	17.22

* Navigation through lock suspended six days on account of high water, and seven days to repair lock gate.

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APPENDIX H H.

IMPROVEMENT OF HARBORS ON LAKE SUPERIOR.

REPORT OF CAPTAIN W. L. FISK, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Harbor at Grand Marais, Minnesota.
2. Harbor at Agate Bay, Minnesota.
3. Harbor at Duluth, Minnesota.
4. Harbor at Superior Bay and St. Louis Bay, Wisconsin.
5. Minnesota Point at Superior, Wisconsin.
6. Harbor at Ashland, Wisconsin.
7. Harbor at Ontonagon, Michigan.
8. Eagle Harbor, Michigan.
9. Harbor at Marquette, Michigan.
10. Harbor of refuge at Grand Marais, Michigan.

EXAMINATION AND SURVEY.

11. St. Louis River, Minnesota and Wisconsin, from Grassy Point, in St. Louis Bay, to Fond du Lac.

UNITED STATES ENGINEER OFFICE,
Duluth, Minn., July 1, 1892.

GENERAL: I have the honor to transmit herewith annual reports upon works of river and harbor improvement at present in my charge for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

H H 1.

IMPROVEMENT OF HARBOR AT GRAND MARAIS, MINNESOTA.

On the north shore of Lake Superior there are very few localities where safe anchorage for vessels can be found, and Grand Marais offers the only harbor of refuge during storms between Agate Bay and Pigeon River, the international boundary, a distance of 120 miles. It is not yet a shipping port of much importance, but it is so near the rich iron ore deposits of the Vermillion Range that it is probable a railroad will soon be built to connect it with them.

The approved project of 1879 is to build two breakwater piers, each 350 feet long, from the east and west points of the bay, or one pier 700 feet long from the east point, and dredge an anchorage area of about 26 acres to a depth of at least 16 feet, all at an estimated cost of $139,669.40.

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The object of this work is to provide a harbor for purposes of refuge and commerce, which it has fully accomplished as far as completed.

The improvement of the harbor commenced in 1880; at the present time the length of completed breakwater is 350 feet, or one-half of the whole, and the 16-foot anchorage is 21.5 acres in extent, or a little more than four-fifths of that contemplated by the original project.

The anchorage is compact in shape and fairly well protected, but this space is not of sufficient size to permit more than one or two vessels to maneuver with safety. The harbor is so small its entire area, 61 acres, should be utilized. To do this in the best manner would require 500 feet extension of the breakwater, and additional dredging to the amount of about 450,000 cubic yards. The extension of the breakwater would cost about $100 per foot, or $50,000; the additional dredging, at the present contract price of 20 cents per yard, would cost about $90,000 more, which, with 10 per cent for contingencies, would make a total of $154,000 to complete this excellent harbor. The original estimate of the cost of improving this harbor was $139,669.40, but contemplated protecting and dredging only a part of it.

During the year small repairs were made to the breakwater, which is in good condition.

The contract under way at the date of the last annual report was completed the following August, 70,850.9 yards having been dredged during the fiscal year just closed, or a total under the contract of 100,780 yards.

This work is in the collection district of Duluth, Minn. Duluth, Minn is the nearest port of entry. The nearest light-house is situated on the breakwater at Grand Marais.

Abstract of appropriations for improving harbor at Grand Marais, Minn.

By act of Congress—		By act of Congress—	
Approved March 1, 1879	$10,000	Approved August 5, 1886	$10,000
Approved June 14, 1880	10,000	Passed August 11, 1888	15,000
Approved March 3, 1881	20,000	Approved September 19, 1890	22,350
Passed August 2, 1882	20,000		
Approved July 5, 1884	10,000	Total	117,350

EXPENDITURES.

Amount expended under approved project to June 30, 1892	$115,883.71
Balance available July 1, 1892	1,466.29

ESTIMATES.

Original (estimated) amount required to complete the improvement	$139,669.40
Amount that can be profitably expended	100,000.00

Money statement.

July 1, 1891, balance unexpended *	$22,922.18
June 30, 1892, amount expended during fiscal year	21,455.89
July 1, 1892, balance unexpended	1,466.29
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	11,466.29
Amount (estimated) required for completion of existing project	12,319.40
Amount that can be profitably expended in fiscal year ending June 30, 1894	100,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

* The balance unexpended July 1, 1891, as shown in Annual Report for 1891 is $22,888.85; the difference, $33.33, is amount disallowed on Voucher No. 1, item 1, fourth quarter, 1891.

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COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Grand Mairas, Minn., for 1891.

Designation.	Arrivals.	Clearances.	Total.
Coastwise	96	97	193
Foreign	64	62	126
Total	160	159	319

Tonnage of vessels could not be obtained. No new lines of transportation were established.

Freight received and shipped, 1891.

Receipts:	Tons.
Grain	2
Flour	60
Coal	30
Salt	2
Cement	4
Lumber	17
Shingles	2
General merchandise	112
Miscellaneous	4
Total	233

Shipments:	Tons.
Fish	20
Cedar posts	1,800
Building stone	150
Miscellaneous	1
Total	1,971

The increase of tonnage in shipments is due to the export of cedar for building purposes.

Freight received and shipped for ten years.

Year.	Tons.	Value.	Year.	Tons.	Value.
1882	224	$25,691	1887	312	$29,059
1883	239	27,595	1888	460	44,871
1884	270	30,198	1889	252	29,349
1885	390	41,484	1890	275	32,035
1886	475	48,519	1891	319	32,687

Arrivals and clearances of vessels for ten years.

Year.	Arrivals.	Clearances.	Year.	Arrivals.	Clearances.
1882	134	134	1887	164	164
1883	131	131	1888	190	190
1884	152	158	1889	168	168
1885	188	190	1890	268	268
1886	210	210	1891	160	159

H H 2.

IMPROVEMENT OF HARBOR AT AGATE BAY, MINNESOTA.

Agate Bay is a small indentation of the north shore of Lake Superior, and although it has ample depth of water it is not protected from the southwest or from the reverse swells of the more dangerous storms of the northeast; but the little security it afforded was sufficient to warrant the construction of extensive ore docks and docks for the

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handling of merchandise. The commerce soon grew out of all proportion to the size of the harbor, and for the security of this commerce it was necessary to supplement the natural protection by artificial means.

The approved project of 1887 is to construct two breakwater piers on a line towards each other from the eastern and western points of the bay, to be 1,000 feet and 900 feet long, respectively, leaving an opening of 1,340 feet between their extremities and inclosing an area of 109 acres.

The original estimate of cost was $213,000, which was increased to $244,208 in Annual Report of 1887 on account of higher prices.

The object is to protect shipping at the wharves which otherwise would be greatly exposed. Work was commenced in 1887 on the east pier, which, including 200 feet built under the contract in progress at date of last annual report, is now 750 feet in length, leaving 250 feet to be built to complete it, while nothing has been done on the west pier; the work is therefore a little more than one-third done, but the remaining two-thirds will cost considerably more than twice what has already been expended, for the reason that it is in much deeper water.

There is not yet perfect security from southwest storms for vessels lying at the merchandise dock, but it is no longer necessary to leave the harbor and seek security elsewhere. The favorable results already obtained with the portion of the breakwater now built are much greater than anticipated, and emphasize the advisability of speedily completing the remainder of the projected piers.

During the past winter the Duluth and Iron Range Railroad put in a third large ore dock, which it is now extending to about double the capacity originally intended, and will soon put in two more, making five in all.

To protect vessels at these new docks as much as possible, the next work should be done on the west pier, and in order to give good shelter the entire 900 feet of it should be completed; this would cost about $135,000, and this amount could be profitably expended during the year.

The Iron Range is the only railroad using this harbor as a shipping point, and the business of the place has heretofore been entirely subsidiary to the iron-ore interests of the Vermillion Range, but the immense quantities of excellent iron ore recently developed in the Missabe Range bid fair to be quite as important as the former and are likely to seek an outlet through Agate Bay. Of iron ore alone there were shipped from this port during the season of 1891, 1,000,052 net tons.

Agate Bay (known locally as Two Harbors) is in the collection district of Duluth, Minn., which is also the nearest port of entry. The nearest light-house is situated on the east point, Agate Bay, Minnesota.

Abstract of appropriations for improving harbor at Agate Bay, Minnesota.

By act of Congress:	
Approved August 5, 1886	$22,500.00
Passed August 11, 1888	15,000.00
Approved September 19, 1890	25,000.00
Total	62,500.00

EXPENDITURES.

Amount expended under approved project to June 30, 1892	$61,384.59
Balance available July 1, 1892	1,115.41

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ESTIMATES.

Estimated amount required to complete the improvement	$181,708.00
Estimated amount required annually for preserving and maintaining when improvement is completed	2,000.00

Money statement.

July 1, 1891, balance unexpended	$26,244.21
June 30, 1892, amount expended during fiscal year	25,128.80
July 1, 1892, balance unexpended	1,115.41
Amount appropriated by act approved July 13, 1892	30,000.00
Amount available for fiscal year ending June 30, 1893	31,115.41

Amount (estimated) required for completion of existing project	151,708.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	135,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Vessels arriving and departing at Agate Bay, Minnesota.

Year.	Vessels.	Estimated tonnage.	Increase.
1885	174	295,800	.....
1886	263	460,000	164,200
1887	465	697,500	237,500
1888	749	1,436,000	738,500
1889	1,255	2,400,000	964,000
1890:			
Steam, 968	1,050	2,625,000	225,000
Sail, 82			
1891:			
Steam, 1,188	1,250	2,915,000	290,000
Sail and whaleback, 62			

Receipts and shipments.

Year.	Ore shipped.	Other freight received and shipped.	Total.
	Tons.	*Tons.*	*Tons.*
1885	225,484	10,895	236,379
1886	304,396	21,954	326,350
1887	394,252	6,620	400,872
1888	509,964	30,352	540,316
1889	924,054	31,731	955,785
1890	984,215	37,268	1,021,483
1891	1,000,052	41,181	1,041,233

Estimated value of freight received and shipped. (Exclusive of ore.)

1887	$96,000
1888	212,000
1889	222,000
1890	246,000
1891	225,000

There were no new lines of transportation established last year.

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H H 3.

IMPROVEMENT OF HARBOR AT DULUTH, MINNESOTA.

THE CANAL, OR ENTRY.

The question of ownership of the land occupied by the canal is still unsettled, and is somewhat complicated owing to the deed of the city of Duluth to the platted lots having been accepted in part only by the act of Congress of August 11, 1888, to the claims of the late Mr. Wilhelm Boeing to property not included in the deed but covered by the canal, and to the fact that the city of Duluth has never vacated to the United States the underlying portions of streets.

No work of any kind was done on the canal piers during the year, but a contract has just been let for placing a new pierhead crib at the end of the south pier and repairing the old one, which has been badly damaged by ice and threatens the safety of the outer light-house. There is no question of land ownership at this point.

The north pierhead has also been considerably damaged, although not so badly as the other. It will, however, soon require repairing.

There is now on hand for repairs to piers something over $14,000, which has been reserved from various appropriations for the harbor, but the contract just let will require, including inspection expenses, something over $10,000, leaving available for emergencies only about $4,000. As the piers are old and the superstructure considerably damaged and decayed, $25,000 should be available for repairs. There is now over 20 feet of water nearly the entire length of the canal, and 12,000 yards of dredging will give an available depth of 22 feet through.

While the piers were built for a depth in the canal of only 12 feet they show no signs of giving way with an existing depth of from 18 to over 30 feet, which means that they will not have to be rebuilt at present for the new 22-foot channel.

THE HARBOR BASIN.

No work has been done upon the harbor basin during the year, and no complaints of shoaling have been heard. This basin should be enlarged where it joins the new channel east of Rice Point, as boats are constantly backing out from one wharf to move to another, and with probably less than a half dozen exceptions all vessels bound to West Superior this season have come in through the canal and passed through this basin and the new channel over to the West Superior wharves. At least $75,000 could be profitably expended in this work during the next year.

RICE POINT CHANNEL.

The dredging for the new channel east of Rice Point was commenced in 1889, but as the funds alloted were not sufficient to give a navigable channel through, it was not carried beyond the old dike. When the river and harbor act of 1890 was passed the opening of this channel was considered of such importance that authority was given by the Secretary of War to continue the dredging upon the terms of the 1889 contract without losing the time necessary to advertise for new bids, and an agreement to that effect was entered into with Williams, Upham &

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Co., the former contractors. The act of Congress was signed on the 19th of September, and dredging was begun on the 24th. When work stopped for the season sufficient had been done to permit the passage of large boats with careful handling by tugs.

An examination of the channel made just before the breaking up of the ice in April, 1891, showed that it had held unexpectedly well, but had a least width between 15-foot curves of only 45 feet. Work was resumed on the 28th of that month, as soon as the ice would permit, the channel carefully trimmed up and widened, until when the funds were exhausted, May 28, it had a least width of about 110 feet between 15-foot curves. An examination made during last winter after a full season's use of this channel showed surprisingly good results, the least width between 15-foot curves being 90 feet at two points while the average width throughout was 125 feet. The length of this channel is 1.6 miles. The present project calls for a width in this channel of 200 feet, but in my opinion it should be at least 400 feet to safely and conveniently accommodate the traffic now passing through it. The custom-house records show 1,610 arrivals and departures of vessels from West Superior during the season of 1891, the aggregate registered tonnage being 2,064,463, of which over 99½ per cent used this channel. In addition it is used by numerous tugs, light or with large rafts of logs in tow, and the large ferryboats make hourly trips in both directions. It is at present by far the most important part of the harbor improvement at the head of the lakes, and $100,000 could be profitably expended upon it during the next fiscal year.

The estimated cost of the 200-foot channel was $119,552, of which $63,000 has already been allotted, leaving $56,552 to complete.

NORTH-SHORE CHANNEL, ST. LOUIS BAY.

With the $40,000 allotted for this channel from the appropriation made August 11, 1888, a channel of such width as could be made at a single cut of a dredge was dug between the deep water at Rice Point and that at Grassy Point. Though it had a depth of 14 feet throughout its length, its width was not sufficient to render it safely practicable for vessels of ordinary size. Important manufacturing industries are now located at Grassy Point, and the obliteration of this insignificant channel by neglect would work a great injury to these important interests and to the commerce dependent upon them. Aside from this, it is a matter of considerable economy to complete such channels as soon as possible, and thus avoid expensive redredging. The river and harbor act of September 19, 1890, gave $60,000 for the continuation of this work. Dredging was begun under the new contract May 28, 1891, and completed on the 17th of October, when this channel had throughout a width of at least 100 feet, and the mills at West Duluth had begun shipping lumber through it. An examination made through the ice during last winter showed the channel to be holding well, as it was in practically the same condition as when work stopped.

The estimated cost of this channel is $163,000. There therefore remains to be supplied $63,000, which amount could be most advantageously expended during the next year.

PARK POINT CHANNEL.

Nothing has been done to this proposed channel.

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HARBOR LINES.

Several instances of illegal dumping of dredgings in the harbor last fall were reported to United States district attorney for Minnesota, under the provisions of the last river and harbor bill. The offender plead guilty and a nominal fine was imposed. Since that time no other cases have been detected.

FURTHER IMPROVEMENTS.

In view of the increased depth adopted for the new lock at Sault Ste. Marie and connecting lake channels, it becomes necessary to submit a revised estimate of the cost of the approved project for this harbor in order that the necessary depths may be available here by the time they are in the lower lake channels.

The approved project calls for an anchorage area inside the canal 3,200 feet long by 1,450 feet wide; a channel east of Rice Point 200 feet wide; a channel 200 feet wide along the north shore of St. Louis Bay from Rice Point to the deep water of St. Louis River at Grassy Point, and a channel along the 2,640 feet of Minnesota Point dock line nearest the canal. At present the anchorage area has a depth of 16 feet throughout; the Rice Point channel is 100 feet wide between 15-foot curves; the channel along the north shore of St. Louis Bay is also 100 feet wide between 15-foot curves; and nothing has been done on the Minnesota Point (Park Point) channel.

With 21 feet in running channels the harbor and its channels should have a depth of not less than 22 feet in order that deep laden vessels in starting and stopping shall not throw up troublesome lumps with their wheels, and on this basis the following amounts must be dredged, viz:

(1) Canal, 12,258 cubic yards, at 15 cents	$1,838.70
(2) Harbor or anchorage area, 847,617 cubic yards, at 15 cents	127,142.55
(3) Rice Point channel (200 feet wide between 22-foot curves), 444,661 cubic yards, at 15 cents	66,699.15
(4) Minnesota (Park) Point channel (200 feet wide between 22-foot curves), 343,211 cubic yards, at 15 cents	51,481.65
(5) St. Louis Bay channel (200 feet wide between 22-foot curves), 758,204 cubic yards, at 18 cents	136,476.72
2,405,951 cubic yards	383,638.77
Contingencies, 10 per cent	38,363.88
Total	422,002.65
Required to complete project as it now exists (16-foot depths)	224,526.00
Increase	197,476.65

It will probably be necessary to dump most or all of the dredged material in the lake, and on account of the long tow the St. Louis Bay work will cost more than the rest.

Of the above items (1), the greater part of (2), and (3) may be classed as urgent, while (5) can probably be done gradually, as its use for the present is almost entirely by lumber vessels, which will not require the maximum depth; (4) is not necessary at present, although it may be in a short time.

The St. Louis River above Grassy Point has a depth of over 10 feet for several miles and 8 feet to Fond du Lac Station. Four or five feet can be carried up to the foot of the rapids, from which point up the river has a fall of about 600 feet in less than 7 miles. The utilization

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of this immense water power has already been commenced, the first dam, located at Thomson, being now about completed and giving a head of 36 feet, but it appears that a deep navigable channel to Fond du Lac is essential to the success of any enterprises in this locality.

The estimated cost of a channel 100 feet wide and 16 feet deep from Grassy Point to the deep pool near Fond du Lac is $112,822.88 (see separate report of survey of St. Louis River herewith),* and $50,000 could be profitably expended on it during next year.

CONDITION OF WORK.

The canal piers are in fairly good condition, but need extensive repairs, particularly the superstructure. The entire work will eventually require to be replaced with more durable material.

The ruling depths in the portions of the harbor dredged by the United States are:

	Feet.
In canal	17
In the inner basin or harbor	16
In channel on north shore of St. Louis Bay	16
In new channel east of Rice Point	16

Résumé of recommendations.

For next year:	
For canal piers	$25,000
For the Rice Point Channel	100,000
For North Shore Channel, St. Louis Bay	63,000
For enlargement and development of harbor basin	75,000
For St. Louis River above Grassy Point	50,000
Total	313,000

This work is in the collection district of Duluth, Minn., which is also the port of entry. The nearest light-house is situated on the outer end of the south pier of the Duluth Canal and a range light is located on the inner end of the same pier.

Abstract of appropriations for improving harbor at Duluth, Minnesota.

By act of Congress approved—	
March 3, 1871	$60,000.00
June 10, 1872	50,000.00
Allotted from act passed March 3, 1873	36,049.20
By act of Congress approved—	
June 23, 1874	10,000.00
March 3, 1875	35,000.00
August 14, 1876	15,000.00
June 18, 1878	30,000.00
March 3, 1879	25,000.00
June 14, 1880	25,000.00
March 3, 1881	40,000.00
By act of Congress passed August 2, 1882	45,000.00
By act of Congress approved—	
July 5, 1884	45,000.00
August 5, 1886	56,250.00
By act of Congress passed August 11, 1888	80,000.00
By act of Congress approved September 19, 1890	100,000.00
Total	652,299.20

The following statement shows the manner in which the appropriations have been expended. The amount expended under the different classes

*Appendix H H 11.

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of work includes the cost of soundings, superintendence, buoying, and contingencies:

Total amount expended to June 30, 1892:	
Breakwater	$110,000.00
Canal piers, etc	77,510.00
Dredging	447,840.68
Total	635,350.68
Expended prior to present project:	
Breakwater	110,000.00
Canal piers, etc	45,698.33
Dredging	114,953.48
Total	270,651.81
Expended under present project (adopted in 1881):	
Canal piers, etc	31,811.67
Dredging	332,887.20
Total	364,698.87

Money statement.

July 1, 1891, balance unexpended		$62,833.73
June 30, 1892, amount expended during fiscal year		45,822.98
July 1, 1892, balance unexpended		17,010.75
July 1, 1892, outstanding liabilities	$62.23	
July 1, 1892, amount covered by uncompleted contracts	10,240.00	
		10,302.23
July 1, 1892, balance available		6,708.52
Amount appropriated by act approved July 13, 1892		125,000.00
Amount available for fiscal year ending June 30, 1893		131,708.52

Amount (estimated) required for completion of existing project	122,026.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	313,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

Abstract of proposals received for constructing a protection crib and repairs to canal pier at Duluth, Minn., opened June 14, 1892, at Duluth, Minn.

No.	Name and address of bidder.	For protection crib, including riprap.	For repairs to old pier-head.	Total amount of bid.
1	Andrew J. Wenzell, Grand Rapids, Mich	$8,600	$3,000.00	$11,600.00
2	Louis Meining, Duluth, Minn	7,859	2,789.20	10,648.20
3	Francis L. McDonald, Duluth, Minn	8,549	1,675.00	10,224.00
4	Fred. H. Quinby and Francis Omeis, Duluth, Minn	8,300	1,700.00	10,000.00
5	William E. Davis and Peter P. Ferguson, Duluth, Minn	8,600	3,183.00	11,783.00
6	James Edward Smith, Marquette, Mich	9,141	2,143.00	11,284.00
7	E. J. Amory, Duluth, Minn	14,500	3,500.00	18,000.00

Contract awarded to Fred. H. Quinby and Francis Omeis with the approval of the Chief of Engineers.

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COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Duluth, Minn., for 1890 and 1891.

Designation.	1890.				1891.			
	Arrivals.	Clearances.	Total.	Tonnage.	Arrivals.	Clearances.	Total.	Tonnage.
Coastwise	1,102	1,125	2,227	2,554,020	1,291	1,301	2,592	3,078,687
Foreign	164	143	307	186,334	153	150	303	189,344
Total	1,266	1,268	2,534	2,740,354	1,444	1,451	2,895	3,268,031

Comparative statement of arrivals and clearances, 1890 and 1891.

Year.	Vessels.	Tonnage.	Average tonnage.
1890	2,534	2,740,354	1,081
1891	2,895	3,268,031	1,129
Increase	361	527,677	48

Principal domestic commodities received and shipped by lake, 1891.

Receipts:	Tons.	Shipments:	Tons.
Coal	778,982	Wheat	499,962
Lime and cement	45,994	Flour	170,774
Lime and building stone	33,312	Oats and corn	3,775
Salt	21,741	Lumber	12,981
General merchandise	270,174	General merchandise	39,190
Total	1,150,203	Total	726,682

Receipts of coal and shipments of flour eastward for nine years.

Year.	Coal.	Flour.	Year.	Coal.	Flour.
1883	420,000	91,896	1888	1,435,000	171,223
1884	372,000	79,801	1889	1,045,000	198,053
1885	695,000	113,190	1890	* 735,995	149,112
1886	736,000	133,036	1891	778,982	170,774
1887	1,041,000	129,627			

* Coal receipts prior to 1890 are given for the head of the lake (Duluth and Superior), since then for Duluth only.

The storage capacity of Duluth elevator system is 21,300,000 bushels, and that of Duluth elevators proper 12,650,000 bushels. The following table gives the receipts and shipments of wheat for twenty-one years.

Year.	Receipts.	Shipments.	Total.	Year.	Receipts.	Shipments.	Total.
Ending Dec. 31—	*Tons.*	*Tons.*	*Tons.*	Ending Aug. 31—	*Tons.*	*Tons.*	*Tons.*
1891	1,144,082	1,058,449	2,202,531	1880	40,430	43,610	84,040
1890	460,244	427,725	887,969	1879	45,722	44,617	90,339
1889	513,827	400,410	923,237	1878	54,092	54,000	108,092
1888	239,802	404,485	644,287	1877	13,817	15,117	28,934
1887	514,089	585,558	1,099,647	1876	43,536	41,292	84,828
1886	675,977	530,048	1,206,025	1875	34,137	32,436	66,573
1885	446,590	421,973	868,563	1874	67,224	72,725	139,949
1884	411,688	346,537	758,235	1873	59,444	47,495	106,939
Ending Aug. 31—				1872	27,948	28,531	56,479
1883	141,234	137,607	278,841	1871	16,703	16,345	33,048
1882	97,987	99,264	197,251				
1881	99,965	85,966	185,931				

The above figures show the movement of wheat at the head of the lake (Duluth and Superior combined).

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Average vessel tonnage for seven years.

	Tons.		Tons.
1885	761	1889	970
1886	778	1890	1,081
1887	812	1891	1,129
1888	887		

Comparative statement of arrivals and clearances of vessels at Duluth for fifteen years.

Year.	Arrivals.	Clearances.	Total.	Year.	Arrivals.	Clearances.	Total.
1877	329	228	567	1885	808	899	1,797
1878	406	343	749	1886	1,026	995	2,021
1879	502	497	999	1887	1,237	1,238	2,475
1880	524	524	1,048	1888	1,100	1,100	2,200
1881	666	660	1,326	1889	1,263	1,265	2,528
1882	833	832	1,665	1890	1,266	1,268	2,534
1883	796	779	1,575	1891	1,444	1,451	2,895
1884	888	903	1,791				

New lines of transportation established: (1) The American Steel Barge Company, capital, $2,500,000; tonnage, 204,000, consisting of five steamers and twelve barges of the whaleback type of construction. One of the steamers carried a cargo of grain to Liverpool, England, via St. Lawrence River, thence to New York and via Cape Horn to Puget Sound. (2) The Eber Ward Line, Ogdensburg, N. Y.; tonnage, 15,000.

Comparative statement of imports and exports.

Year.	Free goods.	Dutiable.	Value of goods in bonded warehouse.	Duties collected.	Domestic exports.
1888	$78,866.00	$8,035.00	.....	$2,909.00	$1,207,858
1889	15,496.00	6,356.00	.....	2,931.00	1,435,447
1890	35,027.40	12,999.73	$806.00	5,255.86	1,521,751
1891	138,041.00	17,485.00	433.00	4,764.34	2,079,173

Opening and closing of navigation.

Year.	Opening.	Closing.	Year.	Opening.	Closing.
1885	Apr. 27	Nov. 29	1889	Apr. 11	Dec. 4
1886	May 7	Dec. 14	1890	Apr. 16	Dec. 8
1887	May 4	Dec. 28	1891	Apr. 30	Dec. 6
1888	May 11	Dec. 31	1892	Apr. 16	.....

H H 4.

IMPROVEMENT OF HARBOR AT SUPERIOR BAY AND ST. LOUIS BAY, WISCONSIN.

The natural channel connecting Superior Bay with Lake Superior is at the southern extremity of Superior Bay. It was originally obstructed by shifting bars with scarcely 9 feet of water over them, to remedy which the citizens of Superior, previous to 1866, had made some attempts at pier work, which was subsequently taken in hand by the United States and the improvements continued until the piers have reached an aggregate length of 5,650 feet.

When the improvement was commenced 12 feet depth in the channel

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was more than sufficient to meet the requirements of the largest vessels. This depth has been increased and maintained for some time at 17 feet, and at no distant day will have to be still further increased to 22 feet. The crib piers which define this channel are in most part badly conditioned for the present depth of 17 feet, they having been intended originally for not over 12 feet. A further increase in the depth of the channel may possibly make it necessary to replace them with better-proportioned structures.

In the meantime the superstructures will have to be extensively repaired. In fact, extensive repairs are urgently needed now, but the $15,000 held in reserve for this purpose is not safely sufficient to meet the damages liable to result from a single severe storm. It is in reality an emergency fund, and until something more is in sight can not be properly used in making general repairs. It is in the interest of economy as matters stand at present to postpone all general repairs to the latest moment pending the consideration of the subject of reconstruction, but it is hoped that the greater portion of the present substructure cribs can be retained. In any event it will be necessary to maintain a reserve fund for repairs of all kinds until the general repairs are completed. At present this should not be less than $15,000.

The shore on the Wisconsin side is advancing rapidly, and soon the sand which drifts around the end of the Wisconsin pier will necessitate the extension of this pier. If this extension is to provide for 22 feet depth it will cost $30,500.

CHANNEL IN SUPERIOR BAY.

The channel in Superior Bay has neither the directness nor width to permit vessels to reach Connor Point safely without the assistance of a tug or local pilot, though its condition has been vastly improved in the past few years. Its present condition is good, but vessels bound for West Superior will not use it so long as the shorter and much easier route through Duluth Canal is in good condition. It is used considerably, however, by rafts, and should not be allowed to deteriorate.

In order that vessels may navigate this channel at all times safely it is essential that it be widened and straightened considerably.

During the next year $50,000 could be advantageously expended in continuation of this work.

QUEBEC DOCK CHANNEL.

No work was done on this channel during the year.

THE NEMADJI RIVER.

The commerce on the Nemadji River is increasing, owing to the location upon its banks of sawmills and brickkilns which depend upon the water transportation it affords to get their products to market.

The bar at its mouth is a serious obstruction and was dredged during last year, but will probably require redredging each year after the spring floods to maintain a serviceable channel; this will require about $5,000 annually.

CHANNEL ALONG WISCONSIN DOCK LINE, ST. LOUIS BAY.

The projected channel between Connor Point and Grassy Point along the West Superior dock line will be about 12,500 feet in length; of this

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6,000 feet now averages about 200 feet wide between 15-foot curves and the 2,500 feet dredged last year averages about 135 feet between the same curves of depth. During the fiscal year 119,614 cubic yards were dredged in extending this channel and 46,261.3 cubic yards in widening it near the Northern Pacific Railroad Bridge.

The width is hardly sufficient to permit vessels to enter or leave the dock slips safely. There is great danger of their colliding with the farther bank and injuring their steering or propelling apparatus in doing this. Furthermore, this movement is a slow one, and practically blocks the channel until the maneuver is completed. The channel should be widened to 400 feet in the vicinity of the docks. The sum of $75,000 could be judiciously expended in the improvement of this channel during the ensuing year.

DEEPENING OF CHANNELS.

In view of the increased depth adopted for the new lock at Sault Ste. Marie and connecting lake channels, it is necessary to submit a revised estimate of the cost of the approved project for this harbor in order that the necessary depths may be available here as soon as they are in the lower lake channels.

The approved project originally provided for maintaining piers at the natural entry, dredging between them a channel 300 feet wide and 16 feet deep, a channel 150 feet wide from the entry past Nemadji River to Quebec Dock, a channel up Nemadji River 100 feet wide, and a channel 100 feet wide from Quebec Dock along the west side of Superior Bay to the St. Louis River, opposite Connor Point. To this has been added by Congress a channel along the West Superior dock line of St. Louis Bay 200 feet wide.

The existing conditions are as follows:

The entrance has a depth of 16 feet, also the channel to Quebec and Northern Pacific Docks; nothing has been done on the channel along the Superior Dock line between Quebec Dock and Connor Point, but there is a 16-foot channel crossing Superior Bay diagonally from the entry to Connor Point; the channel up Nemadji River has never been improved, but a narrow channel 12 to 14 feet deep was dredged through the bar at the mouth of the river last year; and the channel in St. Louis Bay along the West Superior Dock line has a depth of 16 feet for about two-thirds of its length, nothing having been done on the other third.

With 21 feet in running channels, the harbor and its channels should have a depth of not less than 22 feet, in order than deep-laden vessels in starting and stopping shall not throw up troublesome lumps with their propellers, and on this basis the following amounts must be dredged, viz:

(1) Lake outside the entry, 7,432 cubic yards, at 15 cents	$1,114.80
(2) Entry, 140,019 cubic yards, at 15 cents	21,002.85
(3) Main channel (diagonally from entry to Connor Point), 1,425,055 cubic yards, at 15 cents	213,758.25
(4) Quebec Channel, 162,481 cubic yards, at 15 cents	24,372.15
(5) Channel from Quebec Dock to Connor Point along dock line, 1,494,570 cubic yards, at 15 cents	224,185.50
(6) West Superior Channel in St. Louis Bay, 905,687 cubic yards, at 18 cents	164,033.66
4,135,244 cubic yards	648,467.21
Contingencies, 10 per cent	64,846.72
Total	713,313.93

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It is probable that nearly all this material will have to be dumped in the lake, and on account of the longer tow the St. Louis Bay work is likely to cost more than the rest.

Of the above items (1), (2), (4), and half of (6) are urgent, while if (5) is completed (3) will not be necessary, at least for a long time.

At least $100,000 could be profitably expended on this work during next year.

CONDITION OF WORK.

The entry piers are in fair condition, but need extensive repairs, particularly the superstructure, to render them secure. The beach protection is still intact, although insufficient. The ruling depths in the channels dredged by the United States are:

	Feet.
From Connor Point to the entry	16
From Northern Pacific Railroad Dock to the entry	16
In front of Quebec Dock	16
Throughout the entry between piers	16
Channel in St. Louis Bay	16

RECOMMENDATIONS FOR NEXT YEAR.

For reserve fund for entry piers	$15,000
For extension of the south pier of entry	30,500
For the channel in Superior Bay	50,000
For dredging at the mouth of the Nemadji River	5,000
For channel in St. Louis Bay	75,000
For beginning deepening of channels	100,000
Total	275,500

Superior, West Superior, and Connor Point are in the collection district of Superior, Wis., Marquette, Mich., being the port of entry. The nearest light-house is situated on the outer end of north pier of the Superior entry.

Abstract of appropriations for improving harbor at Superior Bay and St. Louis Bay, Wisconsin.

By act of Congress approved—	
March 3, 1867	$63,000.00
April 10, 1869	45,000.00
July 7, 1870	40,000.00
March 3, 1871	60,000.00
June 10, 1872	50,000.00
Allotted from act approved March 3, 1873	63,950.80
Allotted from appropriation for "repairs of harbors on northern lakes"	5,433.00
By act of Congress approved—	
August 14, 1876	3,000.00
June 18, 1878	3,000.00
March 3, 1879	5,000.00
June 14, 1880	5,000.00
March 3, 1881	10,000.00
August 2, 1882	40,000.00
July 5, 1884	45,000.00
August 5, 1886	22,500.00
By act of Congress passed August 11, 1888	50,000.00
By act of Congress approved September 19, 1890	65,000·00
Total	575,883.80

EXPENDITURES.

Amount expended under original project adopted in 1867	$258,000.00
Amount expended under project recommended by Board of Engineers in 1873	77,513.26
Amount expended under present project to June 30, 1892	218,827.60
Total	554,340.86

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The following statement shows the manner in which the appropriations have been expended. The amount expended under the different classes of work include the cost of examinations, soundings, superintendence, buoying, and contingencies:

Repairs and beach protection	$13,233.00
Construction and repairs to piers	318,443.53
Dredging	222,664.33
Total	554,340.86

Money statement.

July 1, 1891, balance unexpended	$71,674.65
June 30, 1892, amount expended during fiscal year	50,131.71
July 1, 1892, balance unexpended	21,542.94
Amount appropriated by act approved July 13, 1892	70,000.00
Amount available for fiscal year ending June 30, 1893	91,542.94
Amount (estimated) required for completion of existing project	156,736.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	275,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Superior, Wis., for two years.

Year.	Arrivals and clearances.	Tonnage.
1890	1,256	1,541,777
1891	1,610	2,064,463
Increase	354	522,686

Average vessel tonnage.

1890	1,228
1891	1,282
Increase	54

Of the number of vessels reported above for 1891, 1,452 were steam and 158 sailing vessels.

The storage capacity of the Superior elevators is 8,300,000 bushels.

Shipments and receipts by lake of leading articles during season of 1891.

Shipments:	Tons.	Shipments—Continued.	Tons.
Wheat	524,786	Copper ore	15,455
Other grain	2,654	Lumber	10,440
Flour	155,860		
Wool	1,000	Total	710,195

Receipts:	Tons.
Coal	877,988
Cement	2,480
Sugar	13,599
General merchandise	12,386
Total	906,453
Total receipts and shipments	1,616,648

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Comparative statement of receipts and shipments for 8 years.

Year.	Tons.	Year.	Tons.
1884	17,462	1888	327,327
1885	33,626	1889	1,006,542
1886	117,027	1890	1,495,885
1887	170,020	1891	1,616,648

Comparative statement of arrivals and clearances of vessels for 8 years.

Year.	Vessels.	Tonnage.	Year.	Vessels.	Tonnage.
1884	194	119,288	1888	812	915,816
1885	200	113,519	1889	900	1,122,048
1886	316	283,787	1890	1,256	1,541,777
1887	462	404,780	1891	1,610	2,964,463

H H 5.

IMPROVEMENT OF MINNESOTA POINT, AT SUPERIOR, WISCONSIN.

The approved project for this improvement consisted in building about 1,000 feet of sand fence near the old light-house on the southern extremity of the point to catch the drifting sand and prevent its blowing over into the Superior Channel, which is very close to the shore of the point in this vicinity, and about 200 feet at a low and narrow part of the point, known as "The Opening," about 2 miles north of the old entrance, to form a bank which would prevent the lake from cutting through into the bay during storms.

The fences were built according to the plans published in House Ex. Doc. No. 51, Fifty-first Congress, first session.

Work was begun by the contractors shortly before the opening of navigation and completed during the season of 1891.

This work is in the collection district of Duluth, Minn. The nearest light-house is situated on the outer end of north pier of the Superior entry.

Money statement.

July 1, 1891, balance unexpended	$368.41
June 30, 1892, amount expended during fiscal year	322.49
July 1, 1892, balance unexpended	45.92

H H 6.

IMPROVEMENT OF HARBOR AT ASHLAND, WISCONSIN.

The southern end of Chequamegon Bay forms the harbor of Ashland, and as the length of the bay is considerable it was necessary to protect the wharves from the waves to enable vessels to use them at all times. The approved project is for the construction of a pile, slab, and rock breakwater 8,000 feet long, dredging a channel of the necessary depth along the dock line, and closing the breach in Chequamegon Point with a brush and stone dike.

The breakwater consists of three rows of piling filled in with slabs which are held in place by large rock ballast. The construction seems somewhat light, considering the ice in the bay, but has so far answered

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the purpose excellently, with the great recommendation that it is very cheap, costing under last season's contract only $25.95 per running foot as against about $140 per foot for the usual form of crib breakwater constructed in about the same depth of water.

In 1889 a length of 4,650 feet was built, of which 50 feet was subsequently carried away. Under last season's contract 1,080 feet were added to it; its total length now 5,680 feet, and the breach in Chequamegon Point was closed by a brush and stone dike 4,200 feet long. In addition to the new work repairs to the old portion were made to the amount of $3,782. These were rendered necessary by the settlement of the slab filling and the shifting of considerable of the ballast, which was apparently of too small size.

The breakwater is still of insufficient length to give protection to all the wharves of the city, but its influence in diminishing the turbulence of the waters of the harbor is distinctly apparent. To build the remaining 2,320 feet of the breakwater, estimated at present contract prices, will cost $94,000, including probable necessary repairs and contingencies.

A harbor line has been established by the city, but there is not a uniformity of depth along it. To give a channel 200 feet wide and 17 feet deep along this dock line about 425,000 cubic yards of material will have to be excavated. This will cost $93,500, provided no rock is encountered.

In order to give access to the wharves for vessels drawing the full depth that the new lock at Sault Ste. Marie is expected to give, a channel not less than 200 feet wide, with a depth of 22 feet, should be dredged along the dock line by the time the new lock is completed, and to that end work should be begun soon.

This channel will require the removal of 903,497 cubic yards of material, and at 18 cents per yard would cost $162,629.46; adding 10 per cent for contingencies makes the total estimated cost of this channel $178,892.40.

The principal shipments from Ashland are iron ore and lumber.

There is an iron furnace and general machine shop in operation and it is presumed that the other enterprises which are expected to locate here will materially increase the shipments of manufactured articles and general merchandise.

There has been expended during the year just closed $59,400.87 and the total amount expended under approved project to date is $137,138.67.

RECOMMENDATIONS.

For 2,320 feet extension to the breakwater	$70,000
For repairs and contingencies	24,000
For dredging	93,500
Total	187,500

This work is in the collection district of Superior, Mich., Marquette, Mich., being the port of entry; nearest light-house, La Pointe, on Chequamegon Point, at entrance of Chequamegon Bay.

Abstract of appropriations for improving harbor at Ashland, Wis.

By act of Congress approved August 5, 1886	$22,500
By act of Congress of August 11, 1888	60,000
By act of Congress approved September 19, 1890	60,000
Total	142,500

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Money statement.

July 1, 1891, balance unexpended	$64,762.20
June 30, 1892, amount expended during fiscal year	59,400.87
July 1, 1892, balance unexpended	5,361.33
Amount appropriated by act approved July 13, 1892	45,000.00
Amount available for fiscal year ending June 30, 1893	50,361.33
Amount (estimated) required for completion of existing project	142,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	142,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Ashland, Wis., for two years.

Year.	Number.	Tonnage.
1890	4,489	2,750,000
1891	4,099	No record.
Decrease	390	.....

Principal articles of export and import for 1891.

Exports:	Tons.	Imports:	Tons.
Iron ore	1,253,493	Coal	560,480
Pig iron	37,192	Cement	2,222
Stone, building	938,420	Salt	8,254
Lumber	404,904	Fire brick, fire clay	326
Lath	9,750		
Shingles	2,500	Total	571,282
Total	2,646,259	Total receipts and shipments	3,217,541

Comparative statement of receipts and shipments for five years.

	Tons.
1887	1,401,454
1888	1,357,472
1889	1,971,213
1890	2,816,924
1891	3,217,541

Arrivals and clearances of vessels for five years.

1887	892
1888	2,375
1889	3,171
1890	4,489
1891	4,099

H H 7.

IMPROVEMENT OF HARBOR AT ONTONAGON, MICHIGAN.

In 1887 the Ontonagon River, which forms the harbor, had fairly deep water in it, but its mouth was obstructed by a bar which had but

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7 feet depth over it. The project adopted then for the harbor it offered was to build parallel piers projecting into the lake on either side of the river's mouth, the expectation being that the current of the river would have sufficient force to maintain a depth between the piers of 12 feet or more. This expectation has not been fully realized, although the piers are nearly of the proposed length, the east pier being 2,315 feet in length and the west pier 2,675 feet.

It appears that the river during the freshets is heavily charged with sand, and the bar at the entrance forms as fast as the piers are extended. The channel which the river is able to maintain through this bar is shifting and uncertain.

Unless the piers can be speedily extended into deep water, which, owing to the gradual slope of the lake bottom and consequent great expense, is hardly practicable, it does not appear advisable to carry the pier work any farther at present. The improvement of the harbor can probably be more economically pursued by dredging a channel through the bar each year.

The portion of the piers composed of piling is very much decayed and needs replacing. This will cost $15,600. The dredging will cost about $10,000 annually.

The remaining 150 feet of superstructure on the west pier was completed in August last under the contract in progress at the date of the last annual report.

The amount expended during the year was $9,585.39.

The total cost of the improvement to June 30, 1891, was $302,730.76.

As a result of the improvement there was a channel with least depth of 16 feet, but it is likely to shoal again.

This work is in the collection district of Superior, Mich.; nearest port of entry, Marquette, Mich. A light is shown on the outer end of the west pier at Ontonagon, Mich.

Abstract of appropriations for improving harbor at Ontonagon, Mich.

By act of Congress—	
Approved March 2, 1867	$97,600
Approved July 7, 1870	10,000
Approved June 23, 1874	23,000
Approved March 3, 1875	25,000
Approved August 14, 1876	15,000
Approved June 18, 1878	15,000
Approved March 3, 1879	17,000
Approved June 14, 1880	15,000
Approved March 3, 1881	20,000
Passed August 2, 1882	20,000
Approved July 5, 1884	15,000
Approved August 5, 1886	13,000
Passed August 11, 1888	12,500
Approved September 19, 1890	10,000
Total	308,100

EXPENDITURES.

Amount expended under approved project to date	$306,643.08
Balance available July 1, 1892	1,456.92
Estimated amount required annually for preserving and maintaining (dredging)	10,000.00
Estimated amount required for repairing piers	15,600.00
Total	25,600.00

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Money statement.

July 1, 1891, balance unexpended *	$11,042.31
June 30, 1892, amount expended during fiscal year	9,585.39
July 1, 1892, balance unexpended	1,456.92
Amount appropriated by act approved July 13, 1892	20,000.00
Amount available for fiscal year ending June 30, 1893	21,456.92
Amount (estimated) required for completion of existing project	35,670.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	35,670.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, ONTONAGON, MICHIGAN.

Not being able to obtain the statistics for the years 1889, 1890, or 1891, I append those for the calendar year 1888.

Arrivals and clearances of vessels.

Year.	Arrivals.	Clearances.	Tonnage.
1887	174	174	222,000
1888	120	120	188,100

Principal articles of export and import.

Articles.	1887.	1888.
Exports:	*Tons.*	*Tons.*
Lumber	28,929	42,858
Copper	119	143
Fish	140	12
General merchandise	200	98
Total	29,388	43,111
Imports:		
General merchandise	1,600	1,665
Grain	600	.....
Flour	504	.....
Meats	26	.....
Salt	47	.....
Coal	500	1,050
Live stock	.....	26
Dressed lumber	.....	22
Total	3,277	2,763

H H 8.

IMPROVEMENT OF EAGLE HARBOR, MICHIGAN.

This harbor was improved in order to form one of the harbors of refuge for this shore of Lake Superior. The entrance to the small bay

* The balance unexpended July 1, 1891, as shown in Annual Report for 1891, is $10,989.94; the difference, $52.37, is amount credited to this appropriation on account of fuel drawn by Maj. Charles E. L. B. Davis, Corps of Engineers, U. S. Army, as per transfer settlement from Third Auditor's Office, November 12, 1891.

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which forms the harbor was obstructed by a rock ledge having but 8½ feet of water over it at the shoalest part.

The project for its improvement was adopted in 1866, but was modified in succeeding years, so that, as carried out, it provided for a channel through the rocky ledge 130 feet wide and 14 feet deep, marked by two guiding cribs, one on each side of the channel.

This work was completed in 1879 and appears to meet the present demands of commerce.

The amount expended to June 30, 1892, was $94,713.67.

Nothing is required at present for the improvement or preservation of this harbor, as the funds available will probably be sufficient to keep the work in good condition for several years.

Modified estimate (see Report of Chief of Engineers, 1876, II, 328; 1877, I, 98; II, 845)	$97,000
Appropriated	97,000

Name of harbor, Eagle Harbor, Michigan; collection district, Superior, Michigan; nearest light-house, Eagle Harbor, Michigan.

Money statement.

July 1, 1891, balance unexpended	$2,486.33
June 30, 1892, amount expended during fiscal year	200.00
July 1, 1892, balance unexpended	2,286.33

COMMERCIAL STATISTICS, EAGLE HARBOR, MICHIGAN.

Not having been able to obtain commercial statistics for the years 1887, 1888, 1889, 1890, or 1891, I append those for the calendar year 1886:

	Tons.
Exports:	
Copper	1,200
Imports:	
Coal	15,000
Lumber	858
Total	17,058

H H 9.

IMPROVEMENT OF HARBOR AT MARQUETTE, MICHIGAN.

The project for the improvement of this harbor was adopted in 1868. It contemplated the erection of a breakwater composed of timber cribs ballasted with rock and extending from the shore into the bay a distance of 2,000 feet. This breakwater was completed, practically as proposed, in 1875.

In consequence of the increasing shipments of iron ore from this port the past few years the area protected proved to be too small for the needs of the shipping engaged in this commerce. In fact, one of the largest ore docks is outside its shelter from the most dangerous storms. The extension of the breakwater became necessary some time ago, and

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provision was made for the commencement of this extension in the river and harbor bill of August 11, 1888.

The contract under this appropriation was for 180 feet extension of the breakwater, but after getting all the embankment and cribs in place two of the latter were carried away by a severe storm, leaving as the net result of the season's work 180 feet of embankment and one crib 60 feet in length. Considerable damage was also done to the remainder of the pier.

There was much speculation as to the integrity of the riprap foundation, but examination made through the ice, and since, proves that it suffered no injury. From this it appears that where there are no deflecting surfaces or obstructions reaching to or above the surface of the water there is but little force exerted by the waves at 14 feet depth.

The extension of the breakwater is in an exposed place, and it is useless to attempt to carry on work upon it during the stormy seasons of the year. There does not, however, appear to be any necessity for altering the plan of construction materially, for where the cribs and superstructure are finished the pier is sufficiently strong. As a precaution during the building, however, the cribs should be decked over with heavy timber as soon as filled with rock, as otherwise the rock is liable to be scooped out by the waves and the stability of the crib destroyed. This can be safely done in those cases like Marquette, where the cribs are set upon a substantial riprap foundation, as there would be but little chance for the ballast to escape, and even if some did escape the superstructure would not be affected, and therefore the stability of the whole structure would be preserved.

The contract in progress at date of last annual report was for 120 feet of crib work and superstructure on the 120 feet of embankment, from which the cribs were taken by the storm, and 120 feet of entirely new work, embankment, cribs, and superstructure, making a total extension of breakwater of 240 feet. The remaining 700 feet of extension is very much needed, and the estimated cost at last contract prices is $98,000; contingencies, etc., $9,800; a total of $107,800. In addition, probably not less than $15,000 will be required for repairs to old work during the period of construction.

The superstructure of the portion of the breakwater commenced in 1866 and finished in 1875 has been extensively repaired, but is nevertheless not as secure as is to be desired. Much of the timber has already been in place several years longer than the usual life of timber in this climate, and the time is short, if it has not already arrived, when this timber work must be replaced by more permanent material.

A project for a concrete superstructure was prepared, and was approved February 27, 1890. This superstructure is estimated to cost $232,936.71, of which sum $100,000 could be expended judiciously in one year.

Harbor lines were established by the honorable Secretary of War in January, 1889, and a reconsideration of the subject occurred upon the application of the Duluth, South Shore and Atlantic Railway Company. Pending the action of the honorable Secretary of War upon this new motion, the railroad company extended the ore dock, as prayed for in the petition. I am not advised as to the final action upon the railroad company's petition, but no complaints from interested citizens of Marquette or from owners or masters of vessels visiting this port have so far been received regarding these extensions beyond the harbor lines,

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from which it is to be inferred that the encroachment is rather viewed as advantageous to all concerned.

RECOMMENDATIONS FOR NEXT YEAR.

For pier extension	$107,800
For concrete superstructure to old work	100,000
General repairs	15,000
Total	222,800

Abstract of appropriations for improving harbor at Marquette, Mich.

By act of Congress approved—	
March 2, 1867 (allotment)	$85,000
April 10, 1869 (allotment)	26,730
July 11, 1870	25,000
March 3, 1871	60,000
June 10, 1872	50,000
March 3, 1873	15,000
June 23, 1874	15,000
March 3, 1875	15,000
August 14, 1878	2,000
June 18, 1878	2,000
March 3, 1879	1,500
June 14, 1880	1,000
By act of Congress passed August 2, 1882	16,000
By act of Congress approved—	
July 5, 1884	5,000
August 5, 1886	10,000
By act of August 11, 1888	25,000
By act approved September 19, 1890	40,000
Total	394,230

Money statement.

July 1, 1891, balance unexpended	$44,459.42
June 30, 1892, amount expended during fiscal year	29,798.60
July 1, 1892, balance unexpended	14,660.82
July 1, 1892, outstanding liabilities	100.00
July 1, 1892, balance available	14,560.82
Amount appropriated by act approved July 13, 1892	80,000.00
Amount available for fiscal year ending June 30, 1893	94,560.82
Amount (estimated) required for completion of existing project	275,736.71
Amount that can be profitably expended in fiscal year ending June 30, 1894	222,800.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, MARQUETTE, MICHIGAN.

Arrivals	1,540
Clearances	1,540
Tonnage	2,867,020

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Principal articles of export and import.

Exports:	Tons.	Imports:	Tons.
Iron ore	1,057,830	Coal	148,560
Pig iron	4,862	Limestone	1,057
Lumber	40,000	Sandstone	2,857
General merchandise	3,000	Lumber	2,475
		Brick	3,087
		General merchandise	20,000
Total	1,105,692	Total	178,036

Vessel tonnage.

Year.	Tonnage.	Average tonnage.
1890	3,077,566	1,061
1891	2,867,020	931
Decrease	210,546	130

There have been no new lines of transportation established.

H H 10.

IMPROVEMENT OF HARBOR OF REFUGE AT GRAND MARAIS, MICHIGAN.

The harbor of Grand Marais, Michigan, was only accessible for vessels drawing less than 9 feet. Once within the bay, there is ample depth to float the largest vessels. As a harbor of refuge it is of pressing importance to the shipping navigating the Lakes in this vicinity, as the many wrecks in this neighborhood bear witness.

The project for the improvement of this harbor was adopted in 1881, and has for its object the creation of a safe entrance into the bay for vessels of the largest size. The entrance channel is to be about 300 feet in width, protected by crib piers on either side. The west pier is now 1,406 feet long, including 100 feet of pile dike, and the east pier is 853 feet long, including 100 feet of pile dike.

A channel 150 feet wide and 17 feet deep was dredged out between the piers in 1889. As the sand was piled up between the piers at the inner ends to the height of the superstructures, it was not supposed that the dredged channel would remain open, but it was believed that while the waves and currents might level the sand between the piers and obliterate the channel no accessions of sand were anticipated. An examination was made in June, 1890, and, compared with the survey made in 1888, showed considerable change. The sand had been leveled and distributed over a rather larger area than was expected, and, although no accession of sand appears to have occurred, the character of the bar and the condition of the shore at the inner ends of the piers would indicate that a large quantity of sand had been washed into the channel and afterwards washed out.

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The storm of December 26, 1890, carried away the end of the west pier with its superstructure, lodging it between the piers near the inner end of the east pier. It is too badly damaged to be replaced even if money were available for that purpose.

A more substantial form of protection at the inner ends of the piers than that originally constructed appeared essential, particularly for the east pier, as the water had cut through behind it.

Two contracts were made for work at this place last year. One was for building new shore end on east pier with protecting spurs on the outside, remodeling old shore ends of piers, and repairing the damaged outer ends. The other was for dredging between the piers. In addition $250 was expended in repairing damages that occurred after the contracts were let.

The new shore end of the east pier, with its protecting spurs, seems to have fully accomplished its purpose of closing the cut around the end, and when last visited had gathered a large quantity of sand, apparently securing the shore connection.

Although properly the dredging should have been delayed until the piers were finished, the pressing need of a channel of some kind into the harbor warranted the commencement of this work, and during the year a channel 175 feet wide with least depth of 17 feet was again dredged through and used last fall by several vessels seeking shelter from storms.

During the dredging the crib mentioned as having been left in the channel by the storms in December, 1890, was carried out by another gale and deposited to the eastward of the east pier, where it is entirely out of the way.

To complete the work according to the approved project, 400 feet remain to be added to the west and 900 feet to the east pier. If the extension of the piers continues with reasonable celerity, probably a channel dredged to full 17 feet will not be obliterated, but will preserve a depth sufficient to revive the commercial interests of this place, which are held in abeyance at present for lack of this essential.

Vast lumbering interests lie contiguous to this harbor, which would make it a shipping point in the event of there being a sufficient depth of water in the channel to accommodate the vessels engaged in such business, and I think that it would not be long after obtaining a navigable channel into it before the harbor would claim other distinctions than that of a harbor of refuge.

Original estimate (see Report of Chief of Engineers, 1881, page 2053)	$450,000
Appropriated	231,250

This work is in the collection district of Superior, Mich. Nearest light-house, Big Sable, Mich.

Abstract of appropriations for improving harbor of refuge at Grand Marais, Mich.

By act of Congress—	
Approved June 14, 1880	$10,000
Approved March 3, 1881	20,000
Passed August 2, 1882	40,000
Approved July 5, 1884	35,000
Approved August 5, 1886	26,250
Of August 11, 1888	50,000
Approved September 19, 1890	50,000
Total	231,250

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Money statement.

July 1, 1891, balance unexpended*	$50,369.20
June 30, 1892, amount expended during fiscal year	45,727.26
July 1, 1892, balance unexpended	4,641.94
July 1. 1892, outstanding liabilities	19.20
July 1, 1892, balance available	4,622.74
Amount appropriated by act approved July 13, 1892	30,000.00
Amount available for fiscal year ending June 30, 1893	34,622.74
Amount (estimated) required for completion of existing project	188,750.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	100,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and clearances of vessels at Grand Marais, Mich.

Vessels.	Number.	Tonnage.
Steamers	116	12,000
Sailing vessels	30	8,000
Total	146	20,000

Principal articles of export and import.

	Tons.
Exports:	
Fish	300
Shingles	32
Imports:	
Lumber	20
Hay and grain	600
Iron	4
Imports—Continued.	
Coal	150
General merchandise	100
Miscellaneous	150
Total	1,356

Receipts and shipments for five years.

	Tons.
1887	1,910
1888	6,270
1889	8,686
1890	9,405
1891	1,356

*The balance unexpended July 1, 1891, as shown in Annual Report for 1891, is $50,341.15. The difference, $28.05, is amount credited to this appropriation on account of fuel drawn by Maj. Charles E. L. B. Davis, Corps of Engineers, U. S. Army, as per transfer settlement from Third Auditor's Office, November 12, 1891.

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H H 11.

[Printed in House Ex. Doc. No. 58, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF ST. LOUIS RIVER, MINNESOTA AND WISCONSIN, FROM GRASSY POINT, IN ST. LOUIS BAY, TO FOND DU LAC.

UNITED STATES ENGINEER OFFICE,
Duluth, Minn., October 7, 1890.

GENERAL: Pursuant to the requirements of letter from your office of September 20, 1890, I have the honor to submit the following preliminary report upon the examination of the St. Louis River, from Grassy Point, in St. Louis Bay, Minnesota, to Fond du Lac, or the State line between Minnesota and Wisconsin:

The length of the river channel between Grassy Point and Fond du Lac is 15 miles; the direct line distance is but 8 miles. There is very little fall to the river except for the upper mile of the course. The valley of the river is marshy, and contains numerous ponds, bayous, and cut-offs, which would require examination as well as the main channel, since such features require to be considered in any project for the improvement of the river.

In addition to the topographical and hydrographical examinations the slope and discharge of the river should be determined.

The nature of this examination is such that the field work would have to be done in summer. The estimated cost, including the mapping and preparation of project, is $3,400.

I believe the river is worthy of improvement, although the present navigation is inconsiderable. In substantiation of my belief I respectfully invite attention to the accompanying letters upon the subject. I also append a small map* showing the location of the several interests referred to in the above-mentioned letters.

Respectfully submitted.

JAMES B. QUINN,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. O. M. Poe, Corps of Engineers, Division Engineer, Northwest Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
Detroit, October 10, 1890.

Respectfully forwarded to the Office of the Chief of Engineers, with the following remarks and recommendations, viz:

The rapid advance of all commercial and industrial interests at Duluth and vicinity is manifest, and indicates with a high degree of certainty a great future for the locality.

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*Not printed.

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Already these interests are being established along St. Louis Bay and River to Fond du Lac, and it is probable that long before any considerable progress can be made towards improving the channels of approach by water the necessity for them will be pressing.

In my opinion it is not too early to make the surveys and examinations required for the preparation of a general project for improving St. Louis River upon a scale adequate to meet the prospective demands of commerce.

I believe that St. Louis River, from Grassy Point, in St. Louis Bay, Minnesota, to Fond du Lac, is worthy of improvement by the General Government, and I recommend that the within project for its survey and examination be approved.

O. M. POE,
Colonel, Corps of Engineers,
Engineer, Northwest Division.

LETTER OF ST. LOUIS LAND IMPROVEMENT COMPANY OF DULUTH, MINNESOTA.

DULUTH, MINN., *September 25, 1890.*

DEAR SIR: In the matter of a preliminary survey of the St. Louis River from Grassy Point to Fond du lac, and the demands of commerce for the immediate dredging of the same, it may be of assistance to you to know something of the intentions and purposes of the land companies who are now engaged in developing their properties on said river.

The St. Louis Land Company, which I represent, owns 2,600 acres on the Wisconsin side, comprising sections 14, 15, 22, and 23, and lots in front of said sections on said river in township 48 north, range 15 west, Douglas County, about 2½ miles from the St. Louis water power. Our capital stock is $1,000,000, $600,000 of which is invested in these lands. The balance of the stock is to be sold and the cash obtained therefor used for the developing of the same. We have already sold 250,000 and hold the balance ready for sale when we need the money. The cash received from this stock and also from the sale of lots, so far as may be necessary, will be used for securing manufacturing plants, railroads, improving our water front, and the general developing of our town site. The Duluth and Southern Railroad, a new road, will have its terminals, car shops, etc., upon our town site, and will run in a southerly direction, intersecting the Northern Pacific, the Great Northern, the Soo, and a number of other roads in its course to Minneapolis and St. Paul, Red Wing, and some miles farther south.

Engineers have already commenced the survey of this road, and over 17 miles are already under contract to be built within this year. The Northern Pacific is also surveying a route to reach the river at this point. From this point to St. Paul will be some 20 miles shorter than any other road now connecting St. Paul with the head of the lakes. The effect of congregating these different systems of roads at this point must of necessity establish a large system of coal docks, grain elevators, flouring mills, etc.

We have already secured a flouring mill with a capacity of from 6,000 to 7,000 barrels a day, that will commence putting its foundations in within the next ten or fifteen days. Also some six or seven manufacturing plants, each of which is a heavy freight-producer. We purpose continuing to induce manufacturing plants to establish themselves upon our town-site, and expect to establish here a large manufacturing town in a very brief time. The chief reason for locating manufactories at this point is on account of its nearness to the falls of the St. Louis River, with its almost inexhaustible supply of power. A company has already been formed, with a capital of $1,000,000, to purchase this water power of Jay Cook and his associates and immediately commence developing the same by a series of dams that will produce at least 64,000 horse power. This power will be used to generate electricity, which will be transmitted to the manufacturing plants, which are located sufficiently near to render it feasible. The effect of the development of this water power must necessarily be the building of large manufacturing industries along the line of the navigable portions of the river, all of which must of necessity be very much handicapped until they can obtain the benefit of lake navigation.

If a more detailed statement of our plans will be of assistance to you I shall be pleased to render it at your suggestion.

Very truly,

A. C. OTIS,
General Manager, St. Louis Land and Improvement Company.

Maj. JAMES B. QUINN.

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LETTER OF NEW DULUTH LAND COMPANY.

DULUTH, MINN., *September 29, 1890.*

DEAR SIR: We desire to call your attention to the necessity of dredging and improving the St. Louis Bay and St. Louis River to Fond du Lac.

The New Duluth Land Company have secured and are now improving some 2,000 acres of land in sections 2, 3, 4, 9, 10, and 11, in township 48 north, range 15 west, in St. Louis County, Minn.

We have already secured industries, both wood and iron working, to employ 1,200 men constantly, and are now negotiating with other industries to employ as many more, with every prospect of locating them during the coming winter.

Among the industries already located will be two large sawmills, which will need water transportation for their output; large iron, brass, and wood working establishments, that will need large quantities of coal to be delivered by water. The St. Louis Water Power Company have contracted, as soon as the falls are improved, to furnish to us power for still larger industries, and there is every reason to believe that the power will be improved so as to furnish this power within the next twelve months.

At Fond du Lac are large brown-stone quarries, shipping large quantities of stone which they are obliged to barge down the river.

The Northern Pacific, and St. Paul and Duluth, and Duluth Short Line railroads already pass through our property and have partial terminals at New Duluth, our new townsite. The Duluth and Southern, a new road projected from Duluth to Red Wing, bisecting all roads between St. Paul and Duluth, is already under contract and expect to build their first 100 miles this winter, and expect to bridge the St. Louis River between St. Louis and New Duluth and have their terminals at New Duluth. The Duluth and Winnipeg Road will also have their terminals in part at New Duluth. South Shore and Atlantic, the Soo Road, and Superior Terminal Company will all enter New Duluth over the bridge of the Duluth and Southern, and will make New Duluth their point for transfer.

We are negotiating now with the Duluth and Northern and expect to secure the terminals of that road at New Duluth. Between Duluth and New Duluth, the St. Louis Bay Land Company and the Ironton Land Company in Minnesota, and St. Louis Land Company in Wisconsin, have already secured large tracts of land and large industries to employ several thousand men, all wanting facilities for water shipment.

In behalf of the New Duluth Land Company we respectfully request that in making your report to the War Department you recommend an appropriation for dredging and improving St. Louis Bay and River for such an amount as you deem advisable and necessary.

Respectfully, yours,

NEW DULUTH LAND COMPANY,
By FRANK R. WEBBER,
President of the New Duluth Land Company.

Maj. JAMES B. QUINN,
Corps of Engineers.

LETTER OF IRONTON LAND COMPANY AND ST. LOUIS BAY LAND COMPANY.

DULUTH, MINN., *September 29, 1890.*

DEAR SIR: We desire to call your attention to the necessity of dredging and improving the St. Louis Bay and St. Louis River from Grassy Point to Fond du Lac.

Within the last six months four important land companies have organized and are making important improvements on the St. Louis Bay and River, and all of said companies have succeeded in securing one or more important industry to be built in the near future. The St. Louis Bay Land Company owns land in sections 14 and 23, and the Ironton Land Company land in section 23, township 49, range 15, St. Louis County, Minn., and have secured the Ironton Steel Works, a manufacturing establishment which will make sheet iron, structural iron, etc., and employ in the neighborhood of 1,000 men.

They will build a dock, and expect to receive coal and other freight from the East, and part of their manufactured products by boat to Milwaukee, Detroit, and other cities on the chain of lakes. The other land companies referred to are the New Duluth Land Company, which has 2,000 acres of land in sections 2, 3, 4, 9, 10, and 11, township 48, range 15, St. Louis County, Minn., and the St. Louis Land Company, which owns land in sections 14 and 15, 22, 23, 48-15 in Douglas County, Wis., both of which have already secured industries which will want facilities for receiving coal and freight from the East and shipping part of the products East also by boat.

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In behalf of the St. Louis Bay Land Company and the Ironton Land Company we respectfully request that in making your report to the War Department you recommend an appropriation for dredging and improving said St. Louis Bay and River of such an amount as you may deem necessary and advisable.

Most respectfully,

IRONTON LAND COMPANY,
By E. L. EMERY,
Manager.

ST. LOUIS BAY LAND COMPANY,
By C. E. LOVETT & CO.,
Agents.

Maj. JAS. B. QUINN,
Corps of Engineers.

SURVEY OF ST. LOUIS RIVER, MINNESOTA AND WISCONSIN, FROM GRASSY POINT, IN ST. LOUIS BAY, TO FOND DU LAC.

UNITED STATES ENGINEER OFFICE,
Duluth, Minn., November 10, 1891.

GENERAL: I have the honor to submit the following report on the survey of "St. Louis River from Grassy Point, in St. Louis Bay, to Fond du Lac, or the State line between Minnesota and Wisconsin."

The preliminary examination was made by Maj. James B. Quinn, Corps of Engineers, who reported the river worthy of improvement and recommended an allotment of $3,400 to make a complete survey of the portion under consideration. The amount allowed, however, was but $600, and with this it has only been possible to check up a survey made in 1884–'85, as described in the report of Assistant Engineer J. H. Darling, herewith, to which reference is made for details.

The portion of the river susceptible of improvement terminates about 1 mile above Fond du Lac, the village being 14½ miles by water above the Grassy Point Railroad bridge, and 20¼ miles from the Duluth Canal. About 4½ miles above Fond du Lac is the foot of the Dalles, which extend about 4 miles up the river, and in which the fall is 480 feet.

From the natural pool at the boom just below Fond du Lac down to Grassy Point there is practically slackwater, and as the river carries little or no sediment any improvements made would be practically permanent. As will be seen from the chart,* this part of the river consists of a succession of long, deep pools (usually with 18 feet or more of water in them) separated by comparatively short bars, with minimum depths of 7½ to 12 feet over them, so the amount of excavation necessary to make a channel the entire distance 100 feet wide at bottom and 16 feet deep, including 8 per cent increase in volume for scow measurement, is but 410,265 cubic yards. The character of the material to be excavated could not be accurately determined, as the small sum available for the survey would not permit of making borings, but from the best available information it is believed to be sand covered with mud in the lower part, running into clay covered with mud in the upper part of the portion of the river considered. The disposal of the dredgings would be somewhat difficult, as it would probably be necessary to tow to the lake for a dumping ground or rehandle it. However, as dredging has been done this year in St. Louis Bay for 14 cents, probably 25 cents per cubic yard would be a fair estimate, and at this figure the cost of the work would be as follows:

410,265 cubic yards, at 25 cents	$102,566.25
Contingencies, etc., 10 per cent	10,256.63
Total	112,822.88

* Not printed.

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In my opinion this improvement should be undertaken, as there are already very considerable manufacturing interests along this part of the river, and its banks will be the natural location for the new manufactures constantly seeking the head of the lakes.

The manufacturing interests already located on the river above Grassy Point represent actual investment in buildings and plant of over $1,000,000, and exclusive of the sawmills have a capacity sufficient to give employment to nearly or quite 2,000 men.

Among these interests are a large and very complete blast furnace and steel plant, a large establishment for the manufacturing of railroad cars and general work, furniture factories, saw and flour mills, iron works, sash and door factories, hardware manufacturing, brick works, brownstone quarries, etc.

The development of the water power on the river by a company controlling 364 feet of the fall in the Dalles has been begun, and when complete will furnish over 63,000 horse power on the minimum discharge of 2,000 cubic feet per second. Of the ten dams contemplated, No. 1, near the head of the Dalles, was built last spring, gives an available head of about 40 feet, and furnishes power to a large establishment for making a fine quality of pressed brick by patented process, from the slate which is found near it in unlimited quantities; Dam No. 10, near the lower end of the Dalles, is under contract. The ultimate idea seems to be to distribute the power in the form of electricity, and if this is carried out it is altogether probable that the interests using the power would be located on the river below Fond du Lac; this is, of course, purely speculative as yet, but the considerable interests already in existence seem to me to deserve an improvement which can be made at such comparatively small cost.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. O. M. Poe, Corps of Engineers, Division Engineer, Northwest Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
Detroit, Mich., November 19, 1891.

Respectfully forwarded to the office of the Chief of Engineers. I concur in the conclusions reached in this report.

O. M. POE,
Colonel, Corps of Engineers, etc.,
Division Engineer, Northwest Division.

REPORT OF MR. J. H. DARLING, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Duluth, Minn., August 31, 1891.

SIR: I have the honor to report the completion of the survey of the St. Louis River from Grassy Point to Fond du Lac, made under your direction and in accordance with the act of Congress of September 19, 1890, and for which the sum of $600 was appropriated.

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The survey was made in April and May, 1891. The character of the survey and results accomplished are as follows:

SOUNDINGS.

These covered the main channel of the river beginning at a point (marked A on Sheet 1) near Grassy Point and proceeding up to three-fourths mile above the village of Fond du Lac, this being a little above the foot of the rapids, and as far up as it was possible to use a sounding boat.

The length of this main river channel is 13 miles. Soundings were also made in some of the secondary channels, also navigable, and separated from the main channel by islands. Soundings are plotted as taken, correcting only for error of lead line, and no reduction made to any particular plane or stage.

A gauge was set at New Duluth on April 7, with its zero at surface of the water, and readings made thereafter on days in which work was done. This gauge was connected with a bench mark on a large elm tree near a sawmill (as shown on the map), the zero of gauge being 5.169 feet below the bench mark. This bench mark was established by the St. Louis Railway Company and St. Louis and Superior Terminal Railway Company, and is 503.83 feet above their datum plane. This datum plane has not been referred to Lake Superior nor to any known elevation as far as I can learn. The gauge readings may be of use in comparing subsequent surveys with this one.

Following are the dates on which soundings were made, and the readings of gauges at New Duluth and at Duluth:

[+ is above zero; — is below zero.]

Location of soundings.	Date.	New Duluth gauge.	Duluth gauge.	Remarks.
	1891.	*Feet.*	*Feet.*	
From A, near Grassy Point, to B, near New Duluth. Soundings taken through the ice.	April 1	.....	—0.5	
	2	.....	—0.5	
	3	.....	—0.5	
	4	.....	—0.4	
	6	.....	—0.5	
	7	0.0	—0.4	
	8	.....	—0.3	
	9	+0.7	—0.4	Northeast gale on 9th.
	11	+0.4	—0.6	
	15	+0.2	—0.4	
	16	+0.4	—0.3	
Mean	.....	+0.2*	—0.4	
From B, near New Duluth, to the rapids above Fond du Lac. Soundings taken from a boat.	April 25	+0.8	—0.3	
	28	+0.8	—0.2	
	29	+0.8	—0.1	
	30	+0.7	—0.3	
	May 1	+0.5	—0.3	
	2	+0.6	—0.2	
	.....	+0.7	—0.2	

* This mean is taken on the assumption that the stage for April 1, 2, 3, 4, 6, and 8, on which readings were not made, was somewhere between 0.0 and +0.17, which I consider likely from what I observed of the river and weather. See also a memorandum on next page.

Additional gauge readings may be found in the field-notes sounding book.

The Duluth gauge is in Duluth Harbor, near the canal, its zero at the plane of 1873, which is a low-water stage of the lake and harbor, but not extreme low water. The plane of 1873 is 601.2 feet above sea level, and the mean level of the lake is 601.78 feet above sea level.

At the time of setting the new Duluth guage, April 7, 1891, I made this memorandum:

"Mr. Cooper, at New Duluth, who seems to be a builder or contractor and is now putting in a sawmill, tells me that the river has not risen any yet this spring, excepting during a recent heavy northeaster when the water backed up and rose 1 foot, and then went down again; that the water is considered to be now at about the lowest stage that it ever gets, and that it has been known to reach a point 7 feet higher than at present. * * *

"There has been no rain yet to speak of; the snow is thawing gradually for the most part, on one or two days quite rapidly, and considerable now remains. Not much current through the canal." * * *

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It is probable that the stage of water on the river from April 1 to 6 (when no readings were taken) was nearly the same as on the 7th.

Mr. Dever states that he was surveying in the vicinity of Spirit Lake at the time of the great flood in the season of 1888, which was the highest water known for many years (certainly the highest during the seven years that I have been in Duluth), and he observed that the water at that part of the river only rose 2½ or 3 feet above the ordinary level.

The river is not much subject to floods. I have noticed only two during the last seven years, viz, in the spring of 1886 and in the summer of 1888; and the appearance of the banks does not indicate a torrential stream.

It seems improbable to me that the river ever rose as high as 7 feet at New Duluth. Mr. Cooper's information to that effect was at second hand, I believe, and probably unreliable.

In making soundings through the ice, chained courses were run along the channel, of as great length as possible, and lines of soundings run across the channel at right angles to these courses, these lines being 200 feet apart over the shoaler portions of the river, where the depth was less than 16 feet, and from 400 to 800 feet apart on the deeper stretches. Soundings were taken 50 feet apart on the lines, all distances being chained off. The angle which one course made with another was measured with a pocket sextant, and the courses were connected with triangulation stations (stations 4, 7, 10, and some stations near New Duluth).

Soundings in open water (from New Duluth to the rapids) were taken from a boat, which was run across the channel between two sounding stations, at as uniform speed and in as straight lines as possible; and the soundings were made on time, fifteen seconds apart. The distance from shore of the first and last soundings of each line was estimated by eye. The sounding stations were afterward located by stadia.

With the exception of one hour on April 25 and four hours on April 28, a 3-pound lead was used, and a hard braid linen line (made for fishing-trolling), 0.08 inch in diameter, whose length was tested by a steel tape on several dates during the work, and the proper correction therefor was applied to the observed depths in plotting. This sounding line is very rigid and durable. It changes the least in length from use of any that I have ever tried. Following are the tests of the 15-foot tag as taken from the notes:

	Foot short.
April 1	0.16
4	0.15
7	0.19
11	0.12
16	0.15
28	0.13
29	0.15

Some of this variation of 0.07 foot being due to the unavoidable roughness of measuring to a large tag.

For five hours (on April 25 and 28) a 5-pound lead was used, and an imported cable-laid linen line seven thirty-seconds inch in diameter. This line shortened 0.57 foot in 15 feet during this time, and was laid aside for the other line above mentioned. Both of these lines had been in use before, and the larger one had shrunk a good deal and the tags had been reset before the present work. The small line had not been corrected, I believe, since it was made.

The soundings were made by Assistant F. L. Dever.

TRIANGULATION.

The location of soundings and topography is based on a triangulation, which is mainly that of Parkinson's survey, under Major Allen's directions, of 1884–'85. These stations were not permanently marked, and only about one-half of them could be found with certainty. These are marked on the present map with Parkinson's numbers. The missing ones I have replaced by others, set approximately in same position, and relocated them from the nearest known lines of Parkinson's system. These are designated on the map by Parkinson's numbers, but with the letter "a" added. I extended Parkinson's system at the upper end by the addition of stations 21, 23, 24, and 25, and also added stations at several portions of the river, which were not well covered by Parkinson's system. These are designated by Parkinson's numbers with the letter "b" added; thus △ 4b lies between Parkinson's △ 4 and △ 6, etc.

In filling out this system and in testing some of Mr. Parkinson's angles I measured eighteen triangles complete (three angles of each), and one or two angles of seven other triangles, sixty-three angles in all.

I found it necessary to do a considerable amount of cutting of small trees and bushes in reopening Parkinson's lines.

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Such of Mr. Parkinson's angles as I remeasured show a tolerable agreement. These were remeasured not only for testing them, but in order to confirm the identity of the stations found.

Previous to computing my additions to Parkinson's triangulation I found it necessary to compute his triangles from the line △ 4—△ 5 to line △ 20—△ 22 (this being all of his system on the river), taking the angles out from his field notes on account of Mr. Parkinson's computation being lost. I also computed the azimuths and coördinates of his stations and mine. These computations are in Triangulation, an office folio book.

All triangulation stations platted on the map of this survey (excepting △ 4 and △ 9), and also △ 3a, which falls outside of sheet 1, are marked by iron gas pipe, twenty-five in number. Each pipe is 1¾ inches in external diameter, 3 feet long, forged to a point at lower end, and driven vertically into the ground, so as to leave from 2 to 4 inches projecting above the surface. Further description of the stations is given in the field notes of this survey.

The work of measuring the angles, marking the stations with iron monuments, computing the triangles, azimuths, and coördinates, and plotting the stations was by myself.

TOPOGRAPHY.

As stated in a note on sheet 1, the results of this survey are mapped with black ink, while certain portions of the map which it was impossible to cover by this survey for lack of funds, have been copied in sienna color, from the last previous survey, that made by Parkinson in 1884–'85, already referred to.

The method of mapping has been as follows: The results of the present survey were first mapped on mounted drawing paper, which map is to be retained at this office in its incomplete state, and additions made to it later if desired. A copy of this was then made with black ink on tracing linen, sheets 1 and 2 (these forming the map designed for transmittal to Washington). These sheets were then placed upon Mr. Parkinson's map of 1884–'85, adjusted into position by means of the triangulation stations common to the two maps, and the copy made in sienna color of the portions desired to be added. In joining common portions of shore line and channel lines of the two surveys, discrepancies were found, as might be expected; sometimes very small, usually not large, but occasionally large, especially in the case of the shore of swamps, which rise but little above the water. Here a difference in the stage of the river for the two surveys would give different positions for the shore line. Moreover, the survey of 1884–'85 was made in the winter, and during at least the latter portion of that survey the snow was deep, as I know, and this would likely make it hard to tell the position of some portions of the swamp line, and thus be a cause of error. Wherever a discrepancy was found in copying from Parkinson's map the line of his map was bent aside for several hundred feet, usually back from the point of meeting, so as to join on the line of the present survey, the latter not being changed in any case. The present survey as a rule located the shore line immediately adjoining the main channel, and of all channels in which soundings were made. The portion below New Duluth was located mainly by cross-sectioning on the ice at time of making the soundings. Other topography by stadia, angles, and chaining or taping. Some points were located by computed triangles.

This survey located instrumentally section corners and subdivision corners, seventeen in number. These have a small circle drawn around them on the map. The most of these were found marked by stone monuments, a few of them by wooden posts, and one by an iron monument. The permanent monuments established and located at stations and at section corners will be valuable hereafter in laying out United States improvements of the channels or in establishing harbor lines; in locating public and private improvements that may be made and adding same to this map, or in making detached surveys of localities on the river; and in enabling future surveys at any time to be compared with this and with Parkinson's.

The towns of West Duluth, New Duluth, Ironton, and St. Louis have sprung up entirely since Parkinson's survey. These, and that of Fond du Lac, have been mapped by locating instrumentally one or more street or block corners and the direction of a street, and the filling out the remaining streets (as far as deemed best) from recorded plats or other maps and plats considered authentic. Much of the outer portions of West Duluth and of the plat of St. Louis, and to a less extent of the plats of Ironton and Fond du Lac have been omitted for want of room or other good reasons. For filling out the streets of West Duluth Roe's Atlas was made use of, and for mapping the car works, blast furnace, and woolen mills. With this exception, all the buildings and docks shown on the map were located instrumentally.

The work of locating shore line and other topography was by Assistant Dever.

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I have embodied in this map representing the present survey a few locations in vicinity of Grassy Point made by me during the last four years and based on the stations of the present survey, viz, the St. Paul and Duluth Railroad Bridge and approaches, the channel in the vicinity of this bridge as improved by dredging, the West Superior Iron Works Dock, and channel leading to this dock, and two section corners.

The mapping has been done by Assistant Dever and myself conjointly. It is in two sheets on tracing linen, to the scale of 500 feet to 1 inch.

Very respectfully, your obedient servant,

J. H. DARLING,
Assistant Engineer.

Capt. W. L. FISK,
Corps of Engineers.

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APPENDIX I I.

IMPROVEMENT OF PORTAGE LAKE AND LAKE SUPERIOR CANALS, ACROSS KEWEENAW POINT, MICHIGAN, OF HARBORS ON WESTERN SHORE OF LAKE MICHIGAN NORTH OF CHICAGO, ILLINOIS, AND OF FOX AND MENOMINEE RIVERS, WISCONSIN.

REPORT OF MAJOR JAMES F. GREGORY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Portage Lake and Lake Superior canals, across Keweenaw Point, Michigan.
2. Manistique Harbor, Michigan.
3. Cedar River Harbor, Michigan.
4. Menominee Harbor, Michigan and Wisconsin.
5. Menominee River, Michigan and Wisconsin.
6. Oconto Harbor, Wisconsin.
7. Pensaukee Harbor, Wisconsin.
8. Green Bay Harbor, Wisconsin.
9. Harbor of refuge at entrance of Sturgeon Bay Canal, Wisconsin.
10. Ahnapee Harbor, Wisconsin.
11. Kewaunee Harbor, Wisconsin.
12. Two Rivers Harbor, Wisconsin.
13. Manitowoc Harbor, Wisconsin.
14. Sheboygan Harbor, Wisconsin.
15. Port Washington Harbor, Wisconsin.
16. Harbor of refuge at Milwaukee Bay, Wisconsin.
17. Milwaukee Harbor, Wisconsin.
18. Racine Harbor, Wisconsin.
19. Kenosha Harbor, Wisconsin.
20. Waukegan Harbor, Illinois.
21. Fox River, Wisconsin.
22. Operating and care of locks and dams on Fox River, Wisconsin.

UNITED STATES, ENGINEER OFFICE,
Milwaukee, Wis., July 8, 1892.

GENERAL: I have the honor to transmit herewith annual report for the works of river and harbor improvement in my charge for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

JAMES F. GREGORY,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A,

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I I 1.

PORTAGE LAKE AND LAKE SUPERIOR CANALS, ACROSS KEWEENAW POINT, MICHIGAN.

The United States assumed control and charge of these canals on August 3, 1891. The name as above given is now understood to apply to the entire waterway from the western shore of Keweenaw Point to Keweenaw Bay, on the eastern side of the same point (Lake Superior), being the canals proper at either end of the waterway, the cut channels in the bed of the Portage River, and the Portage Lake and River.

As this is the initial report concerning this water route, prepared for publication in the Annual Report of the Chief of Engineers, U. S. Army, it seems proper to review briefly the history of the improvements and their origin as river and harbor improvements of the United States.

An outline map of the waterway and its connections, compiled from the charts of the survey of the north and northwestern lakes and from the latest surveys connected with the improvement, accompanies this report.

The act of Congress approved June 20, 1890, provided for the establishment of new harbor lines in Portage Lake.

The river and harbor act of September 19, 1890, provided for the purchase by the United States "of the two canals known as the Portage Lake and River Improvement Company Canal from Keweenaw Bay to Portage Lake, and the Lake Superior Ship Canal, Railway and Iron Company Canal from Portage Lake to Lake Superior, being the water communication across Keweenaw Point, Lake Superior, from Keweenaw Bay to Lake Superior, in the State of Michigan, by way of Portage River and Lake, and the artificial cut made by said companies to render them available to commerce and navigation, together with the works of improvement on Portage Lake, the harbor works upon Lake Superior and Keeweenaw Bay, with all the lands and franchises connected therewith, free from all incumbrances, three hundred and fifty thousand dollars."

The Board of Engineers constituted by Special Orders No. 112, paragraph 3, Headquarters, Corps of Engineers, Washington, D. C., August 13, 1886, to consider and report upon certain questions under act of Congress approved August 5, 1886, concerning this waterway, made a very full and historical report, dated, Army Building, New York, December 22, 1886, and from it the following matter is extracted:

The report is printed in H. of R. Ex. Doc., No. 105, Forty-ninth Congress, second session.

The southern shore of Lake Superior from Sault Ste. Marie on the east to Duluth on the west, a direct distance of about 375 miles, conforms in general to the 46° 30′ parallel of north latitude, but midway between the two cities the rocky promontory of Keweenaw Point projects northeastwardly into the lake, and compels vessels engaged in the coasting trade to make a wide detour. The shores of this promontory are bold, with outlying reefs, dangerous to navigation, and with no good harbors to afford refuge in storms. All important copper mines of the Lake Superior region heretofore opened lie north of the 46° 30′ parallel of north latitude, near or upon this projecting point.

About 40 miles southwest from its extremity the promontory is cut nearly in a north and south direction by the waterway which forms the subject of this report. Its total length is 24 miles. Of this distance nature has made about 16 miles navigable for all classes of vessels through Portage Lake, which occupies a narrow and deep chasm formed by some ancient convulsion.

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Heading about 2 miles from Lake Superior, on the northwest side of Keweenaw Point, it extends southward, receiving from the east the overflow of Torch Lake. The natural depth of both lakes is ample for all purposes of commerce, present and prospective. They drain, by Portage River into Keweenaw Bay, the great reëntrant formed by the promontory and the southern shore of Lake Superior. The original draft which could be carried through Portage River into the lake was from 3 to 5 feet. To secure this depth on many interior rivers large expenditures are annually made by the Government.

Hancock and Houghton are the chief shipping ports of the copper industry. They lie opposite each other on Portage Lake, about 10 miles from Lake Superior. When the development of the mines had reached such a point as to render the demand for increased facilities of communication imperative, the country was upon the eve of civil war. The work was inaugurated and has been completed without assistance from the General Government.

The project of cutting a ship canal through the ridge of sand and hardpan separating the north end of Portage Lake from Lake Superior was also formed during the war, and a company was incorporated for the purpose. The present canal has resulted, after various changes in organization, which will be considered more in detail below. The General Government has aided this part of the work by appropriating 400,000 acres of public lands. No other assistance was received from the General Government or from the State of Michigan.

These two improvements, although owned by separate corporations, are now practically controlled by the same individuals.

National importance of Portage Lake Route.—Before going into details respecting the history, present condition, and present value of this waterway, its national importance will be considered from two points of view: That of interstate commerce and that of copper production.

Interstate commerce.—The records of the Sault Ste. Marie Canal afford precise data from which to judge of the extent and nature of the commerce of Lake Superior. The following figures exhibit the freight which has passed through the canal during the past five years:

Years.	Registered tonnage.	Actual freight.
1881	2,092,521	1,567,741
1882	2,468,083	2,020,521
1883	2,042,259	2,267,105
1884	2,997,837	2,874,557
1885	3,035,937	3,256,628

* * * * * * *

Col. O. M. Poe, Corps of Engineers, in his reports for intervening years, gives the following statistics of registered tonnage and actual freight passing through the St. Marys Falls Canal from 1886 to 1890, inclusive:

Years.	Registered tonnage.	Actual freight.
1886	3,529,184	3,701,014
1887	4,388,691	4,882,802
1888	4,741,976	5,581,169
1889	7,899,004	8,288,580
1890	8,454,435	9,041,213

There are few ports on the northern shore of Lake Superior at which our vessels find it profitable to trade. They naturally hug the southern shore, on which are situated the centers of the iron, copper, and lumber industries; where are imported immense supplies of coal, lime, building materials, machinery, provisions, and supplies of every kind, and where are exported iron, copper, and lumber. At Duluth and Superior City the exports of grain and imports of every kind needed to develop the new region opened by the Northern Pacific and other railroads swell the traffic to the enormous and increasing figures given above. Keweenaw Point, as already stated, juts far out into the lake and obstructs this natural route of trade.

Again, the prevailing storms of the Lake Superior region are from the northwest and northeast. The natural route of commerce near the southern side lies, therefore, throughout its whole extent along a lee shore. During the summer months

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navigation is usually safe, but in the spring, when the winter accumulations of iron, copper, and lumber demand prompt shipment, and in the autumn, when the wheat crop is pouring from the great Northwest, the lake is stormy and dangerous. Harbors of refuge are urgently needed, not only to save life and property, but also to prevent delays and afford that certainty of rapid transit upon which the low price of freights depends. A vessel liable to be compelled by an approaching storm to linger among the Apostle Islands, it may be for days, before daring to encounter the perils of rounding Keweenaw Point, 'the Cape Horn of Lake Superior,' must charge accordingly. The distance to be traveled before reaching the next harbor of refuge, Marquette, is fully 225 miles, and the whole commerce of Lake Superior is subjected to delays and corresponding increase of rates of freight by lack of intermediate shelter. * * *

Portage Lake, about midway between Marquette and Ashland, would be a perfect harbor of refuge if a western entrance from Lake Superior were provided, safe to enter during storms; at present no such entrance exists.

It appears from the foregoing facts that partly to remove the obstruction offered by Keweenaw Point and partly to secure a needed harbor of refuge, the construction of a ship-canal to perfect the Portage Lake route would now be urged by the navigation interests of the lakes even if private enterprise aided by the Government had not already begun the improvement. * * *

HISTORY OF THE PORTAGE LAKE CANALS.

(*1*) *Portage River improvement.*—By the year 1859 the copper interests centering in Portage Lake had acquired an importance that rendered improved facilities for transportation a necessity. At the mouth of Portage River there was a depth of from 3 to 5 feet over the bar. Vessels arriving there were anchored in the offing, freight was transferred by lighters to docks inside the bar, and there again transferred to scows, upon which it was towed to the mines, a distance of about 14 miles at a cost of $4 per ton. The expense, delay, and annoyance attendant upon this method of procedure led those who suffered therefrom to attempt a remedy by dredging the river and bar and constructing a breakwater. The sum of $30,000 was raised by subscription, the contributors being the Quincy, Pewabic, Franklin, Mesnard, Pontiac, St. Mary's, Albany and Boston, and Isle Royale mining companies, and two merchants and land owners, Messrs. Sheldon and Douglas. Mr. John H. Forster was employed as engineer and a contract was made with Mr. W. W. Williams for securing a channel 10 feet deep and 80 feet wide at bottom. Instead of using the original river mouth the engineer selected a point farther to the east, where he laid out a breakwater and a canal leading to it through a tamarack swamp, the length of cut being 1,200 feet. The object of the breakwater was to prevent the sand moved by northeast storms from filling up the mouth of the canal. Only one pier was considered necessary. It was built during the winter of 1859'-60, the cribs being constructed upon the ice and then sunk and the stone hauled from the quarry upon sleds, the thermometer often running from 20° to 30° below zero. In the month of June, 1860, the first lake steamer was piloted through the canal and river up to the docks in Hancock, though the contract for the improvement was not completed until the autumn of that year. This work was done without the authority of law.

In the following year an act was passed by the Michigan legislature to provide for the formation of companies to construct canals or harbors and improve the same, which act was approved and became law March 13, 1861. Under this law the Portage Lake and River Improvement Company was incorporated, being composed of the persons who had begun the improvement. They were authorized to charge tolls upon all vessels drawing more than 5 feet, the rates being fixed by Houghton County.

The improvement thus far made, great as it was, was very far from being complete. Considerable sums, the exact amounts of which are known only to the company, were expended annually in maintaining and deepening the channel, straightening the river, and placing buoys and beacons. As the trade of the locality increased greater facilities were called for in the use of the waterway. As early as 1865 a depth of 13 feet was called for. In 1874 extensive additional dredging was begun, the object being to obtain a channel depth of 13 feet. In 1875 the old pier was widened and a new superstructure constructed, the old foundation remaining intact then as it does now. Dredging has been continued annually. The income from tolls also increased annually, enabling the corporation to provide for these additional expenses and at the same time to have a handsome profit remaining.

In 1879 the Michigan legislature passed an act, approved May 22, under which any county in which the greater part of a canal or improved river may pass is authorized to purchase such canal or improvement, paying to the improvement company the amount of its capital stock and the amount of all subsequent expenditure in repairs and alterations, with interest at 10 per cent, but deducting from the amount of interest the net proceeds of the improvement.

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Of late years pressure has been brought to bear upon the company to reduce the tolls. In 1885 the rates of toll were reduced by nearly 50 per cent below what they had been up to that time since 1863. The demand now is that the tolls shall be removed altogether, and that the waterway shall be further enlarged. None of the original stockholders now hold any interest in the corporation, and we are informed that the property is now owned entirely by persons nonresidents in the district.

(2) *Lake Superior Ship Canal, Railway, and Iron Company.*—The opening of Portage Lake by means of the improvement of Portage River, to vessels navigating Lake Superior, enabled them to go within a trifle over 2 miles of Lake Superior on the west side of Keweenaw Point. The advantage which would accrue from making the water way continuous from the east side to the west side of Keweenaw Point was obvious, but it involved the construction of an artificial canal 2 miles long, with a breakwater at its entrance from Lake Superior. The expense of such a work was beyond the means of the persons immediately interested in the local trade of Portage Lake, and the benefits to result from it would be national rather than local, while the returns to be expected from the tolls would probably not pay interest upon the investment for many years.

A corporation entitled the Portage Lake and Lake Superior Ship Canal Company was organized under the State laws of 1864, its articles of agreement being filed with the secretary of state of Michigan July 15, 1864. By a joint resolution of the Michigan legislature dated January 21, 1865, Congress was asked to aid the enterprise by a grant of land. The Minnesota legislature passed a resolution to the same effect February 24, 1865. Congress responded by granting to the State of Michigan, by the act approved March 3, 1865, 200,000 acres of land. By act approved March 18, 1865, these lands were conferred by the State upon the above-mentioned corporation, with certain conditions. A plan of construction was then adopted, which was more expensive than had at first been contemplated. Additional aid was sought from Congress by the governor and Representatives of Michigan. The legislatures of Wisconsin and New York passed resolutions February 27, 1866, asking Congress to aid the enterprise. A number of cities also sent in petitions to the same effect. Congress again responded by granting 200,000 additional acres of land by act approved July 3, 1866.

The canal was to be 13 feet deep and 100 feet wide and to be provided with a breakwater at its Lake Superior end. For several years operations were limited to surveying the ground, procuring machinery, and the exploration of lands to be selected under the grant. The original surveys and plans were made by Mr. I. N. Greene, engineer for the State. It was not until 1868 that the work of excavation was actually begun, and at the end of that year only a few thousand yards had been excavated. In the spring of 1869 the work was resumed with great activity, and was vigorously pushed during that and the following year. Mr. John H. Forster superseded Mr. Greene as engineer for the State June 1, 1869. In 1871 the work was embarrassed for want of funds, and made unsatisfactory progress. The title of the company was altered to Lake Superior Ship Canal Railroad and Iron Company. In this year the company failed, and a receiver was appointed by the United States circuit court in Michigan with authority to borrow money for the purpose of completing the canal. The work advanced slowly during the two following years.

The act of Congress making the first grant of land required that the works should be completed by March 3, 1867. The act making the second grant extended this time three years, or to March 3, 1870. The time was subsequently extended to March 3, 1872, and again to March 3, 1873, and finally to December 1, 1873. On the 18th of October, 1873, the State engineer, Mr. Forster, certified that the works were completed according to law, and on the 29th of November, 1873, the governor of Michigan certified that the works were built according to law, but that the title to the lands upon which they were situated being vested in the officers of the company as individuals, and not in the company itself, he did not consider the works completed in accordance with the act of Congress. It was not until June 25, 1875, that the Governor gave his final certificate that the works were completed, the delay being caused by the transfer of legal title required by him. Technically, therefore, the works were completed in 1875, but as a matter of fact they were completed in 1873.

In May 1877, after protracted litigation, the property was sold under decree of foreclosure. It was purchased by Messrs. Mann and Wilson, for the bondholders and creditors of the old company, who organized the present company, under the title of Lake Superior Ship Canal, Railroad, and Iron Company. The consideration mentioned in the deed to Mann and Wilson was $870,000. In the deed from them to the new company the consideration was $100, subject to prior incumbrances amounting to $1,636,385 and accrued interest at 10 per cent. The present company had no connection with the old company.

This canal, independently of the lands attaching thereto, has not proved a financial success. The income from the tolls has been almost wholly expended in keeping it in repair.

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PRESENT CONDITION OF THE IMPROVEMENTS (1886).

The lake survey charts of this vicinity were prepared before the improvement had been completed and no accurate survey of the canal and Portage River improvements had ever been made. Moreover the stamp-mill deposits have largely encroached upon Portage Lake, and demand in the interests of navigation, immediate attention. For these reasons the Board has caused to be made a careful examination and survey (with borings where necessary) of all parts of the route where work is likely to be required by any project for further improvement. This work was promptly and well done by Mr. G. A. Marr, formerly assistant engineer on the survey of the lakes, aided by an efficient party, and the results appear upon four maps, three of them drawn upon a scale of 1″=400′, and one upon a scale of 1″=100′. They are forwarded with this report. Mr. Marr's detailed report is appended, marked N.

The following description of the route is based upon the notes of this survey and upon a personal inspection made by the Board in October, 1886.

In considering the navigable depth of the canal as indicated by the soundings, oscillations of the lake surface can not be neglected. A continnous gauge record has been kept above the locks at Sault Ste. Marie since November, 1870, which shows that besides the temporary and irregular changes of level due to winds there is an annual and an abnormal oscillation. In consequence of the former the water-surface is usually about a foot higher in the months of July, August, and September than in the months of February, March, and April, the change occurring principally in the intermediate months. The gradual abnormal oscillations often cover several consecutive years, as appears from the records for sixteen years at Sault Ste. Marie, furnished by Gen. Poe, appended, marked E. The extreme oscillation during the fifteen years has been 3 feet, occurring between September, 1876, and March, 1880.

During the progress of the surveys ordered by the Board a daily gauge record was kept in Portage Lake. To connect this with the levels of the lake survey a comparison was made, during calm weather, on November 9, 1886, with the nearest benchmark (at Marquette). The water there stood 601.32 feet above sea level. The corresponding elevation at Sault Ste. Marie was 601.62. Upon this basis the average stage of water at Portage Lake during the survey was assumed at 601.4 feet above sea level. The corresponding mean level at Sault Ste. Marie (601.62) was 0.36 foot below the grand mean for October and November during sixteen years. The maximum oscillation at Portage Lake during the survey was 0.3 foot above and 0.3 foot below the average stand; but these readings were only temporary.

Portage Lake.—Of the 24 miles covered by this route about 16 miles traverse Portage Lake. This is a long and narrow sheet of water, with a depth usually varying from 30 to 40 feet, and presenting no natural obstacle to any class of vessels ever likely to navigate Lake Superior. The width is rarely less than 1,000 feet. The banks are usually high, affording perfect protection against gales. In a word, after an entrance has been effected no better harbor of refuge could be desired.

Two artificial obstructions to navigation exist. A low railroad and viaduct bridge between Houghton and Hancock, with a center pivot draw affording only 68 feet clear space, and eight projecting masses of deposit from the stamp-mills, five from the Atlantic, Huron, Franklin, Quincy, and Pewabic, now in active operation. Information upon this subject has already been called for by Congress, and reported upon by Maj. H. M. Robert, Corps of Engineers, House Ex. Doc. 85, Forty-seventh Congress, second session.

The Board was informed that the second section of the river and harbor act of August 5, 1886, was urged upon Congress with special reference to abating these stamp-mill deposits which, unless checked, must soon destroy the value of the lake as a route for through commerce. Our survey was therefore extended (map No. 2) to cover the entire region affected by them, and proposed harbor lines have been indicated thereon for the action of the Honorable Secretary of War. The necessity of at once putting a stop to these deposits can not in our judgment be too strongly stated if this route is to be made a national highway for the commerce of the lakes.

Portage River.—Portage Lake is connected with Keweenaw Bay by a river now artifically shortened to about 5 miles in length (see map No. 3). Originally it was tortuous and obstructed by two bars, one at its exit from the lake and the other at its entrance into the bay. Only from 3 to 5 feet could be carried over these bars, although for long distances the natural channel was much deeper. At present by dredging and cutting off points, a navigable and tolerably straight channel averaging over 100 feet in width, with a minimum depth of 14 feet has been secured. The banks are low, and no revetment has been placed to preserve the cuts.

For the harbor entrance at Keweenaw Bay a single pier has been built, projecting 675 feet from the shore line to 14 feet of water. It was originally made of a single row of timber cribs 12 feet wide, loaded with stone; but a second line was subsequently added, so that now the width is from 25 to 30 feet. While not an elegant construction it serves the immediate needs of commerce in the comparatively sheltered

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position it occupies, and the Board heard no complaints as to dangers encountered at this entrance in storms.

As already stated, all the improvements in this part of the route have been made without cost to the Government, by private enterprise. No outlay has been made to secure a title to the bed of the river, but the sites of the cuts have been purchased by the company, and it is proposed to transfer a clear title to them, as set forth in the statement appended, and marked F.

The Ship Canal.—This canal is 2.1 miles long. Our soundings indicate a depth of 14 feet throughout its whole extent. The least width at water surface is 100 feet, widening to over 200 feet in the Lilly Pond, and thence maintaining 100 feet nearly to Portage Lake. The southern half (near Portage Lake) traverses a swampy region, where no especially difficult work is required for enlargement. The northern half involves more outlay in its extension through an old tamarack swamp and a range of sand ridges 30 feet high with a hardpan bottom outcropping near Lake Superior. Enlargements here would be more expensive.

Throughout the whole extent of the canal its revetment consists of a front row of piles generally about 6 feet apart from center to center, capped a few inches above the water surface to support a single row of sheet piling; a row of anchor piles is driven about 7 feet back and connected with the front row by timber braces. The piles seem generally to be well preserved, but the caps are often decayed and the sheet piling requires frequent repairs to maintain it in position. The superintendent, Mr. Pryor, states that experience has shown that where the route traverses sand hills double the number of piles should be used and a double sheet piling should be driven. As now built, if the space behind is solidly packed the piles are pressed out of position; if it be left open, the waves entering the canal in storms tear off the sheet piling.

Harbor entrance at Lake Superior.—The entrance to the canal is formed by two approximately parallel piers of substantial crib-work which have resisted the storm waves and ice floes in a satisfactory manner since completed in 1873. The hardpan bottom of indurated clay upon which they rest has been of marked advantage in preserving their stability. These piers, 1,000 and 850 feet long, are of timber and stone of the usual pattern. They are 100 feet apart at the shore line, widening irregularly to 240 feet at the lake entrance, where the depth at the date of our survey was 20 feet. Annual dredging is necessary here. The ice during the winter is said to pile up in a solid mass, forming an artificial shore line, which tends to cause accumulations, and thus aggravates the usual creeping of sand around the ends of the piers.

The problem of constructing an entrance to the canal, safe for large vessels during the great storms which prevail on Lake Superior in the spring and autumn, is a difficult one. The tops of the present piers rise 6 feet above the surface of the lake when calm. The Board visited the place during a moderate gale from the westward on October 20. The rollers were coming in with their solid crests fully up to the top of the cribs. Where the defective trace presented surfaces normal to the direction of motion spray was thrown many feet into the air and solid water poured over the woodwork in large volumes. The wave oscillation extended into the canal quite perceptibly for 300 or 400 feet. We were informed that in the great northeast and northwest gales, when the wind blows more directly in the line of the canal, wave motion is felt half a mile from the lake.

If a harbor of refuge is to be made at this place it is a matter of vital importance to render the canal entrance safe in storms. A report upon the subject by Maj. H. M. Robert, Corps of Engineers, will be found in Senate Ex. Doc. No. 32, Forty-sixth Congress, second session. * * *

Project.—The river and harbor act of September 19, 1890, provided: "That for the purpose of preserving and continuing the use and navigation of said canal the sum of $10,000 for each of the present and the next fiscal year be appropriated."

There is no other approved project; but in the pending river and harbor bill provision is made for improving the water communication across Keweenaw Point, Lake Superior, from Keweenaw Bay to Lake Superior, in the State of Michigan, for a navigable depth of 16 feet with a minimum width of 70 feet at the bottom and for repairs to existing revetments.

Present works.—There are no locks. The present works consist of entrance piers at the harbor entrances on Lake Superior and Keweenaw Bay, canals and canal revetments, dredged cuts and channel-ways; also lights and buoys, for aids to navigation, as hereafter described.

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Depth of water.—After dredging last season at the bar between the ends of and outside the piers of the Lake Superior entrance, there was a passable channel through the canals of 12½ feet depth of water. There is a channel 15 feet deep for the greater part of the canals, but a few shoal places reduce the governing depth to about 12½ feet at a stage of water 601 feet above sea-level; the average height of the water-surface of Lake Superior for the last season. Fluctuations in the depth of water in the canals are quite marked; a change of 0.8 foot having been observed even on quite calm days.

Navigation of the canals closed on November 30, 1891, the last boat on that date having the assistance of a tug in order to get out; and was resumed on April 26, 1892.

Operations during the fiscal year.—As heretofore stated, the charge of the canals was assumed by the United States on August 3, 1891. Mr. G. A. Marr was appointed assistant engineer in local charge, and under instructions from this office he established an office for the work in Houghton, Mich., on the 11th of the same month.

The work for the rest of the current fiscal year has been for the care and preservation of the canals, in surveys and examinations at points where dredging and other work was to be done, and in maintaining the buoyage of Portage River, range lights, at the head of the river in Portage Lake and the light at the Portage Lake end of the Upper Canal. A watchman was kept at this canal to prevent violation of the rules and regulations for the navigation of the canals.

Under date of February 11, 1892, the Secretary of War granted permission to the Standard Oil Company to lay a pipe line across Portage Lake in the vicinity of Houghton and Hancock, Mich. Instructions were accordingly given to the assistant engineer in local charge to see that the pipe line was laid in accordance with the terms of the permission granted.

The work done was paid for from two appropriations, viz: "Preservation of Portage Lake and Lake Superior Canals," and "Harbor lines in Portage Lake," as follows:

Preservation of Portage Lake and Lake Superior Canals.—The river and harbor act of September 19, 1890, contained the following provision: "That for the purpose of preserving and continuing the use and navigation of said canals the sum of $10,000 for each of the present and the next fiscal year be appropriated, or so much as may be necessary to pay the actual expenses of operating and keeping said canals in repair." As the canals were not accepted by the Government until August 3, 1891, the first $10,000 appropriated reverted to the Treasury, and therefore only $10,000 for care and preservation has been available.

Under agreement with Williams, Daugherty & Upham, of Duluth, Minn., at 25 cents per cubic yard, the bar between and outside the ends of the piers at the Lake Superior entrance was dredged through, removing 14,300 cubic yards of material. The work was completed August 31, giving a channel of 16 feet between the piers and 18 feet outside them.

A break in the west pier at the Lake Superior entrance was repaired by bolting on new timbers and filling the cribs with stone.

Soundings were taken on cross sections 50 feet apart for the length of the Upper Canal, and also in the four cuts in Portage River and at two shoal sections, making in all about 9,000 feet of river surveyed.

In making the examinations in Portage River, flag buoys were set

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along each side of the channel in about 12 feet of water. As these proved to be of great assistance to vessels in making the channels at these points, they were left in place until the close of navigation.

Early in May, 1892, soundings were again taken at the Lake Superior entrance, which showed that a bar had formed between the outer ends of the piers and outside for a distance of 300 feet, with only from 11 to 12 feet of water on line with the center of the canal, where there was 18 feet at the close of navigation last season.

Under agreement with Mr. James Pryor, of Houghton, Mich., dredging was begun May 16 and finished June 1, 1892, 6,384 cubic yards of material being removed, at a cost of 25 cents per yard.

This opened a channel about 60 feet wide and 17 feet to 18 feet in depth of water outside and about 15 feet between the piers.

A small amount of dredging (included in above-stated amount) was done in the channel, opposite the light-house, which gave relief at a very troublesome point.

The funds being exhausted further dredging was suspended.

Harbor lines in Portage Lake.—For about 7 miles of Portage Lake, in the vicinity of Houghton and Hancock, harbor lines on each side were established by the Board of Engineers constituted by Special Orders, No. 40, 1890, headquarters Corps of Engineers, in accordance with act of Congress approved June 20, 1890.

The report of the Board was dated December 11, 1890, and received the approval of the Assistant Secretary of War January 5, 1891.

These harbor lines were established to prevent encroachments on the channel of Portage Lake by the various copper-mining companies whose stamp mills were located on the border of the lake.

At present the Franklin and the Atlantic are the only companies that dump their stamp refuse into the lake. They are erecting bulkheads to prevent the refuse getting into the channel, and their dumps are closely watched to see that they do not encroach on the harbor lines. Surveys and soundings are made from time to time to illustrate the condition of the banks.

Copper smelting works that dump slag and cinders, electric-light plants that dump ashes, and all other establishments that are likely to dump refuse into the lake have been furnished with printed circulars containing the laws of Congress applying to such cases and have been warned not to infringe them.

Rules and regulations.—A new set of rules and regulations for the navigation of the canals were prepared and received the approval of the honorable the Secretary of War, April 5, 1892. They have been printed and distributed, and no objections on the part of those who use the canals have been made to their enforcement, except in the case of some representative lumbermen in regard to one of the provisions of Rule 5, which directs that "rafts shall be made up with logs parallel to each other, in the direction of raft lengths, secured and held closely together by frequent cross sticks, chains, or cables." These lumbermen think it a hardship and an unnecessary expense to them to be obliged to make up their rafts as described in the rules. It appears to me both reasonable and necessary that rafts should be so made up that they will not inconvenience general navigation more than is necessary and do as little damage to the canal banks as possible, and that to accommodate these conditions the logs should be parallel to each other and not merely boomed. In order, however, that the matter may receive proper consideration upon sufficient data, I directed Lieut. H. E. Waterman,

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Corps of Engineers, to investigate and report upon the methods of making up rafts on the Upper Mississippi River and its tributaries and on Lake Superior and Keweenaw Bay. His report and accompanying sketches illustrative thereof are appended.

APPROPRIATIONS.

Act of September 19, 1890, for the purchase of Portage Canals	$350,000.00
Act of September 19, 1890, for maintenance to June 30, 1892	10,000.00
Act of September 19, 1890, for harbor lines, Portage Lake	5,128.70
Act of July 13, 1892, for improving canals	50,000.00
Total	415,128.70

Money statements.

Portage Lake and Lake Superior canals, across Keweenaw Point.

Appropriated, act of September 19, 1890	$10,000.00
June 30, 1892, amount expended during fiscal year	9,833.65
July 1, 1892, balance unexpended	166.35
July 1, 1892, outstanding liabilities	166.35
Amount appropriated by act approved July 13, 1892	50,000.00
Amount (estimated) required for completion of existing project	1,245,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Harbor lines in Portage Lake.

Appropriated, act of September 19, 1890	$5,128.70
June 30, 1892, amount expended to end of fiscal year	2,817.78
July 1, 1892, balance unexpended	2,310.92

REPORT OF LIEUTENANT H. E. WATERMAN, CORPS OF ENGINEERS.

MILWAUKEE, WIS., *June 30, 1892.*

SIR: In accordance with your instructions I have visited the seat of the logging industry on the Upper Mississippi, and have the honor to submit the following report on the methods employed:

I first went to Winona, intending to visit the grounds at the mouth of Beef Slough, but found that all work had been stopped there by high water. I then went to Stillwater, on Lake St. Croix, which I found to be the very place desired, as here the raftsmen have to contend with no more current than exists on the Great Lakes. All rafts have to be pushed downstream by boats for a long distance.

The logs are floated down the St. Croix River loose, and then made up in sections or strings. Each string is about 40 or 50 feet wide by nearly 400 feet in length, four of them constituting a complete raft. Each string is entirely surrounded by a log boom. The logs of this boom overlap so as to act as fenders, *i. e.*, going downstream the upper end of the lower log will be outside the lower end of the upper log. They are united by a single link chain attached to a hard-wood pin in each log. This pin is illustrated about half size in Fig. 6. The link is shown in Fig. 4. The two are fastened by this method tightly together. At the rear end, where the steamer pushes, a double fastening is used, as in Fig. 5. At the corners, where more play is necessary, a chain of several links is used.

The boom is first placed with the front of the proper width across the river and the two sides pointing upstream, the other end being left open. A row of parallel

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logs is then arranged across the front and the two sides secured by a telegraph wire. Additional logs are now pushed into this row if possible. A second row follows, and so on, the wire cross lines being put on about every 25 feet. When filled the string is closed by the end boom. All of the logs in these operations are pushed in place by men with pevis.

Two strings as above were then united to form a raft or half raft, as they call it. (See Fig. 1.)

The wire lines are now replaced by rope cross lines. "A" lines, as they are called, are also put on, running zigzag across the raft. All these lines are shown on the figure.

All lines are now tightened by a Spanish windlass. One pole is held vertical, while another man inserts a second in the rope, as shown in Fig. 2. The slack is then wound up as in Fig. 3, and when tight enough the windlass is simply laid flat. The logs should be close together, but should not ride, or there is danger of their slipping out of the boom. The steamer is attached to the rear by three lines and pushes the raft instead of towing it.

As far as the application of the above methods in the Portage Lake Canals is concerned, I find the principal difficulty is with the stiff boom. It is all right inside the canals, but on Lake Superior, in a storm, nothing seems to hold as well as a loose boom, viz, the logs not overlapping but connected by about 2 feet of chain. Rafts thus made up have been frequently abandoned during storms on the lake and afterwards recovered unbroken.

The cost of making up with the stiff boom as above described would not exceed 30 cents per M.

It is estimated that the following amounts will be towed through the Portage Lake canals during the present season.

Owner.	Feet, B. M.	Down or up.
Cooch	7,000,000	Down.
Nester	6,000,000	Do.
Hebard	2,500,000	Do.
Smith	2,500,000	Do.
Funke	2,000,000	Do.
Burtis	1,000,000	Do.
Gregory	3,000,000	Up.
Hebard	4,000,000	Do.

This does not include the amounts which may be towed through the Upper Canal, which will probably be small.

It is to be noted, however, that the difficulties in using this method are much greater in the case of rafts bound up Portage River than those bound down. The latter could use a stiff boom through the river and run their logs into a loose one at the entry for crossing Keweenaw Bay, but to reverse the operation requires the making up of the raft in Keweenaw Bay, which might be a serious matter.

On my late visit to Houghton I found that Mr. Hebard and Mr. Funke were making a fair effort to conform to the rule, though not employing the stiff boom. Their rafts are made up of a series of short strings, one in front of the other. Each string is secured on the four sides by eight boom sticks loosely connected, thus forming a square about 30 feet on each side. This square is closely filled with logs laid parallel. It very nearly preserves its shape, and would seem a fair compromise if one is needed.

The rafts towed up Portage River, however, by Mr. Gregory are nothing but sack rafts with a few cross lines, and constitute a serious obstruction. I would recommend that he be notified that he must make more of an effort to conform to the rules. Possibly a cross line at each joint of the boom sticks would accomplish the result. But of course these can only be used successfully by arranging the logs in lines, all parallel to one another.

In conclusion, I would recommend no changes in the rules relating to rafting for the present. They should be given a fair trial by all the owners, as they are unquestionably for the benefit of the canals.

Very respectfully, your obedient servant,

H. E. WATERMAN,
First Lieut. of Engineers.

Maj. JAMES F. GREGORY,
Corps of Engineers, U. S. A.

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Itemized statement of expenses made from appropriation for preservation of Portage Lake and Lake Superior canals, Michigan, act of September 19, 1890.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1891.				
Aug. 11	1	Maj. Chas. E. L. B. Davis	Mileage	$61.76
11	2	do	do	61.76
14	3	First Lieut. H. E. Waterman	do	30.88
14	4	G. A. Marr	Traveling expenses	27.37
15	5	Peter Primeau	Recording deeds	8.00
28	6	F. Mayer & Co	Blue prints	3.44
31	7	G. A. Marr	Services	146.67
Sept. 1	8	Paul Mondor	do	28.00
1	9	S. Mott	do	28.00
1	10	Hired men	Services, August, 1891	57.50
2	11	Des Forges & Co	Stationery	48.90
2	12	Albert H. Travethan	Services	150.00
4	13	James Pryor	Tug hire	36.00
7	14	J. B. Sturgis	Office rent	5.07
12	15	Williams, Daugherty & Upham	Dredging	3,575.20
14	16	F. A. Douglas, agent	Express charges	1.60
21	17	First Lieut. H. E. Waterman	Mileage	39.84
21	18	do	do	30.88
22	19	J. V. Beyer	Labor	40.50
26	20	Joseph Croze	Stone, etc	104.85
26	21	Carl Schmidt	Timber	27.00
26	22	Chas. J. Hodge	Bolts, etc	16.59
29	23	L. Hennes & Co	Rope, etc	10.20
29	24	F. W. Kroll	Stationery	8.00
30	25	G. A. Marr	Services	200.00
30	26	Paul Mondor	do	30.00
30	27	J. B. Sturgis	Office rent	19.00
30	28	S. Mott	Services	30.00
Oct. 2	1	James Pryor	Hire of tug	80.00
2	2	Hired men	Services, September, 1891	60.50
5	3	Lewis G. Palmer	Services, etc	300.00
22	4	Maj. Chas. E. L. B. Davis	Mileage	61.76
22	5	Burdick, Armitage & Allen	Rules and regulations	5.25
22	6	Herman Voss	Books	1.00
28	7	First Lieut. H. E. Waterman	Mileage	61.76
31	8	G. A. Marr	Services	200.00
31	9	Paul Mondor	do	30.00
31	10	S. Mott	do	30.00
31	11	J. B. Sturgis	Office rent	19.00
31	12	H. H. West Company	Book	7.75
31	13	James Pryor	Hire of tug	152.00
31	14	Maj. Chas. E. L. B. Davis	Mileage	62.56
31	15	Hired men	Services, October, 1891	92.00
Nov. 18	16	F. Mayer & Co	Blue prints	5.25
30	17	G. A. Marr	Services	200.00
30	18	Paul Mondor	do	30.00
30	19	J. B. Sturgis	Office rent	19.00
30	20	James Pryor	Hire of tug	32.00
30	21	S. Mott	Services	30.00
Dec. 3	22	Hired men	Services, November, 1891	88.00
3	23	L. Hennes & Co	Oil, etc	10.05
12	24	G. A. Marr	Traveling expenses	13.60
31	25	do	Services	200.00
31	26	Paul Mondor	do	30.00
31	27	J. B. Sturgis	Office rent	19.00
1892.				
Jan. 30	1	Swain & Tate Co	Rules, etc	7.50
31	2	G. A. Marr	Services	200.00
31	3	Paul Mondor	do	30.00
31	4	J. B. Sturgis	Office rent	19.00
Feb. 26	5	G. A. Marr	Traveling expenses	18.05
29	6	do	Services	200.00
29	7	Paul Mondor	do	30.00
29	8	J. B. Sturgis	Office rent	19.00
Mar. 4	9	Henry Blattner	Tapemeasure	12.00
19	10	F. Mayer & Co	Blue prints	2.72
31	11	Paul Mondor	Services	30.00
Apr. 30	1	do	do	30.00
May 4	2	Julius Lando	Thermometer, etc	2.30
10	3	Des Forges & Co	Stationery	32.37
11	4	Eugene Dietzgen & Co	Paper, etc	17.98
13	5	Harvey C. Beeson	Books	2.00
16	6	C. H. Welch	Typewriter, etc	126.45
18	7	Burdick, Armitage & Allen	Rules of navigation, etc	135.00
28	8	Herman Voss	Book, etc	11.25
28	9	Lieut. H. E. Waterman	Mileage	52.96
31	10	Paul Mondor	Services	45.00
31	11	S. Mott	do	5.00

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Itemized statement of expenses made from appropriation for preservation of Portage Lake and Lake Superior canals, Michigan, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1892.				
May 31	12	S. Mott	Services	$30.00
June 2	13	Hired men	Services, May, 1892	189.50
7	14	James Pryor	Dredging	1,596.07
7	15	L. Hennes & Co	Rope, etc	9.89
13	16	Chas. J. Hodge	Steel, etc	3.12
30	17	Paul Mondor	Services	45.00
30	18	S. Mott	do	30.00
30	19	J. B. Sturgis	Office rent	10.00
30	20	James R. Dee	Use of telephone lines	20.00
30	21	G. A. Marr	Services	200.06
		Total		9,833.65

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

Collection district, Superior, Mich.; nearest port of entry, Houghton, Mich. There is a light-house and range lights at each entrance to the canal. Range lights are also kept at the head of Portage River, and a single light on the outer end of the east pier at the Portage Lake entrance to the upper canal.

Before the charge of the canals was assumed by the United States tolls were collected and complete commercial statistics were recorded. Since tolls were abolished the collection of statistics has been more difficult.

Books of blanks for making reports were printed last winter and issued to vessels this spring, the officers of the St. Marys Falls Canal assisting in the distribution of the books by direction of Col. O. M. Poe, Corps of Engineers. Vessel masters or clerks are required to make on these blanks complete returns of their cargoes, directly upon arrival at the first United States post-office after leaving the canals. It is expected that this method will furnish next year complete statistics, or nearly so, of the business of the canals. The statistics reported below are only for the months of September, October, and November, 1891, and are those furnished by vessel agents, mill owners, and others, and are probably within the limit of business done during those months.

Partial statement of class and tonnage of vessels passing through Portage Lake and Lake Superior canals during the months of September, October, and November, 1891.

Bound up.	Number.	Net tonnage.	Bound down.	Number.	Net tonnage.
Steam	164	90,331	Steam	102	41,041
Sail	43	13,220	Sail	22	3,883

Total number of vessels, 331; total net tonnage, 148,475.

Partial statement of freight and passengers carried through the Portage Lake and Lake Superior canals during the months of September, October, and November, 1891.

Bound up.	Net tons.	Bound down.	Net tons.
Coal	48,748	Copper	13,000
Manufactured iron	1,490	Flour	2,649
Salt	130	Building stone	202
Lumber	110	Pig iron	382
Miscellaneous merchandise	23,067	Lumber	6,052
Passengers ... number	179	Logs	36,000
		Miscellaneous merchandise	786
		Passengers ... number	85

Total freight, 132,616 tons; total passengers, 264.

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The following principal lines of steamers used the canals during the season of 1891:

	Boats.
Lake Michigan and Lake Superior Transit Company, Chicago, Ill	5
Lake Superior Transit Company, Buffalo, N. Y	12
Ward's Detroit Line, Detroit, Mich	4
Ward's Lake Superior Line, Detroit, Mich	6

The principal lines ot steamers for the season of 1892 are as follows:

	Boats.
Lake Michigan and Lake Superior Transit Company, Chicago, Ill	5
Lake Superior Transit Company, Buffalo, N. Y	10
Ward's Lake Superior Line, Detroit, Mich	3
Crescent Line, Detroit, Mich	6
Union Transit Company, Buffalo, N. Y	5

Besides the above regular lines of transportation there are a large number of steam barges and sailing vessels using the canals continually, and a large local business is done by tugs towing rafts of logs and timber and scows with wood and lumber. It is now arranged so that all of the above traffic can be reported regularly, and hereafter complete reports of statistics may be expected.

I I 2.

IMPROVEMENT OF MANISTIQUE HARBOR, MICHIGAN.

Object.—To secure a navigable channel from Lake Michigan into the mouth of the Manistique River, where the harbor of Manistique is situated.

Project.—The original project, adopted in 1880, provided for the excavation of about 20,000 cubic yards of material to complete a channel 150 feet wide and 12 feet deep between the piers constructed by local enterprise at the mouth of the Manistique River.

Present works.—No construction work was done by the United States Government. The piers were built and are still owned by private parties.

Depth of water.—Originally there was a depth of 7 feet, which was increased to 10 feet before any appropriation had been made by the Government. A survey made May 12, 1892, showed at that date a channel between the piers of navigable width with a depth of 13 feet. The outer bar was not clearly defined, but the ruling depth over it appeared to be about 11 feet. Dredging by private enterprise was in progress, increasing the depth of water over the outer bar.

Operations during the fiscal year.—There were no operations during the fiscal year ending June 30, 1892.

Remarks and recommendations.—The only work by the United States at this harbor has been the removal of 11,780 cubic yards of material in 1880, under a contract with the Chicago Lumbering Company.

In October, 1880, a survey of the harbor showed that the direction of the piers lay across the natural channel. The company which had built the piers, and had also the contract for dredging, found it necessary at this time to renew about 330 feet of the west pier which had been washed away. The superintendent of the company was notified by the officer in charge, Maj. H. M. Robert, that the pier lines would have to be rectified to conform to the natural channel. The company declined to comply with this demand, and their contract, which had been extended from December, 1880, to June 1, 1881, was annulled.

There have been no operations at this harbor since, and no money is asked for its improvement.

Estimated cost (see Report of Chief of Engineers, 1880, page 1931) $6,000

APPROPRIATIONS.

Act of—	
June 14, 1880	$5,000
March 3, 1881	1,000
Total	6,000

Money statement.

July 1, 1891, balance unexpended	$2,600.76
June 30, 1892, amount expended during fiscal year	31.36
July 1, 1892, balance unexpended	2,569.40

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. J. D. Morserean, secretary Chicago Lumbering Company.]

Name of harbor, Manistique, Mich.; collection district, Superior, Mich.; nearest light-house, Poverty Island, Michigan.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	367	139,753	367	139,753
Sail	299	83,789	299	83,789
Total	666	223,542	666	223,542

Principal articles of export and import.

Exports:	Tons.
Beer	23
Cattle	8
Fish	838
Flour	13
Hides	17
Iron and steel	14,265
Lath	4,271
Lime and cement	62
Lumber	158,646
Merchandise, general	102
Shingles	1,130
Pickets	2,775
Total	182,150

Total approximate value, $1,718,960.

Imports:	
Agricultural implements	17
Apples	86
Beans	29
Beer	147
Brick	80
Butter	49
Cattle	68

Imports—Continued.	Tons.
Cheese	6
Coal and coke	2,000
Corn	31
Eggs	27
Flour	360
Furniture	30
Hay	320
Hogs	31
Iron and steel	967
Cement	174
Merchandise, general	3,528
Mill stuffs	487
Oats	467
Oil	260
Plaster, land	6
Pork and beef	163
Potatoes	23
Salt	585
Sheep	3
Staves	190
Wagons and carriages	11
Total	10,145

Total approximate value, $343,484.

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II 3.

IMPROVEMENT OF CEDAR RIVER HARBOR, MICHIGAN.

Object.—To secure a navigable channel from Green Bay into Cedar River, where the harbor of Cedar River is located.

Project.—The original project, adopted in 1883, provided for the construction of two parallel piers 200 feet apart, extending from the mouth of Cedar River to the 16-foot contour in Green Bay, and dredging a channel between them 14 feet deep; also removing an outer shoal by dredging to a depth of 15 feet.

A modification of this project, approved in 1884, provided for continuing the piers in a direct line with the part already built, instead of at an angle, as originally proposed.

Present works.—Pile piers lined with sheet piling: (1) East pier, 754 feet in length, 16 feet wide; (2) west pier, 301 feet in length, 16 feet wide. All were built in 1883–1885, and are in good condition.

Depth of water.—Originally 8 to 10 feet, obstructed by a 3-foot bar in front of the mouth.

A survey made May 14, 1892, showed a channel 20 feet wide, 12 feet deep, and 10 feet deep with a least width of 40 feet. Dredging by private enterprise to improve the channel was in progress.

Operations during the fiscal year.—There have been no operations during the fiscal year ending June 30, 1892.

Remarks and recommendations.—Work was suspended at this harbor in November, 1885, and has not been resumed by the United States since that date. It is reported that some dredging was done by private enterprise in 1891 and 1892.

In view of the small amount of commerce likely to be benefited by its completion, no appropriation for continuing the improvement has been recommended since 1885.

Original estimate (see Report of Chief of Engineers, 1882, page 2121)...	$138,000

APPROPRIATIONS.

Act of—	
August 2, 1882	$15,000
July 5, 1884	15,000
Total	30,000

Money statement.

July 1, 1891, balance unexpended	$2,218.07
June 30, 1892, amount expended during fiscal year	76.00
July 1, 1892, balance unexpended	2,142.07
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	108,000.00

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. Jesse Spalding, president Spalding Lumber Company.]

Name of harbor, Cedar River, Mich.; collection district, Superior, Mich.; nearest light-house, on north pier head, Cedar River Harbor, Michigan.

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Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	245	61,250	245	61,250
Sail	230	69,000	230	69,000
Total	475	130,250	475	130,250

Principal articles of export and import.

Exports:	Tons.
Bark, tan	187
Fish	30
Hides	7½
Lath	1,430
Lumber	45,000
Poles, telegraph	303
Posts, fence	3,325
Pickets	187
Shingles	1,800
Ties, railroad	14,000
Wood	6,250
Total	72,519½

Total approximate value, $630,000.

Imports:	
Apples	6
Beer	105
Brick	20
Butter	3

Imports—Continued.	Tons.
Cattle	75
Coal and coke	125
Corn	56
Eggs	1
Flour	183
Hay	400
Hogs	7
Lime and cement	21
Merchandise, general	30
Mill stuffs	10
Oats	272
Oil	52
Pork and beef	30
Potatoes	15
Provisions	25
Salt	15
Total	1,451

Total approximate value, $150,000.

I I 4.

IMPROVEMENT OF MENOMINEE HARBOR, MICHIGAN AND WISCONSIN.

Object.—To secure a navigable channel from Green Bay into the Menominee River, where the harbor of Menominee is situated.

Project.—The original project adopted in 1871 provided for the construction of two parallel piers 400 feet apart, extending from the mouth of the river to the 15-foot contour in Green Bay, and dredging a channel between them 14 feet deep. In 1874 it was decided to extend the piers to the 16-foot contour.

Present work.—(1) North pier, 1,854 feet in length, consisting of 585 feet of slab pier, 20 feet wide; 609 feet of pile pier, 481 feet of the same having a width of 14 feet, and 128 feet a width of 18 feet; 660 feet of cribs, 610 feet with a width of 20 feet, and 50 feet with a width of 24 feet. (2) South pier, 2,710 feet in length, consisting of 1,900 feet of pile pier, 1,804 feet having a width of 14 feet and 96 feet a width of 18 feet, and 810 feet of cribs 20 feet wide.

The pile piers were built in 1871–1874, and the cribs 1876–1884. The cribs are in good condition. The north pile pier was rebuilt above the water line in 1889, and is in good condition. The older part of the south pile pier is much decayed, and it should be rebuilt above the water line.

Depth of water.—Originally 4 feet. The channel now is 200 feet wide and 16 feet deep the full length of the harbor piers.

Operations during the fiscal year.—Dredging by hired labor and the use of United States dredges Nos. 1 and 2, resulted in the formation of

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a channel 3,000 feet long, 200 feet wide, and 16 feet deep, extending from the 16-foot contour in Green Bay to the lower end of the channel in the Menominee River of the same width and depth.

Remarks and recommendations.—The full amount of the original estimate for the improvement of this harbor has been appropriated and the object sought is obtained.

A comparison of the surveys made in July, 1889, and January, 1892, show that in the two and a half years intervening the 16-foot contour advanced 1,100 feet on a line in prolongation of the center line of the channel, and that 52,399 cubic yards of material were deposited within the channel limits.

Of the 1,900 linear feet of the south pile pier, built in 1871–1874, at least 1,000 linear feet should be rebuilt above the water line without delay. A section of this pier covering about 315 linear feet was badly damaged by a freshet, the line of piling forming its channel face being undermined, rendering a new line of piling necessary.

An appropriation of $15,000 is recommended to make the repairs now needed to this pier.

Original estimate (see Report of Chief of Engineers, 1874, Part 1, page 139). $212,000

APPROPRIATIONS.

Act of—		Act of—	
March 3, 1871	$25,000	June 14, 1880	$10,000
June 10, 1872	25,000	March 3, 1881	12,000
March 3, 1873	25,000	August 2, 1882	15,000
June 23, 1874	25,000	July 5, 1884	10,000
March 3, 1875	25,000	August 5, 1886	3,000
August 14, 1876	8,000	August 11, 1888	9,000
June 18, 1878	10,000		
March 3, 1879	10,000	Total	212,000

Money statement.

July 1, 1891, balance unexpended (correct amount, report 1891)	$3,255.05
June 30, 1892, amount expended during fiscal year	2,876.73
July 1, 1892, balance unexpended	378.32
Amount (estimated) required for completion of existing project*	15,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	15,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. R. S. Hutchinson, deputy collector of customs.]

Name of harbor, Menominee, Mich.; collection district, Superior, Mich.; nearest light-house, on north pierhead, Menominee, Mich.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	473	99,836	470	100,564
Sail	383	81,687	394	83,131
Total	856	181,523	864	183,695

* For repairs to piers.

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Principal articles of export and import.

Exports:	Tons.
Fish	1,000
Lath	4,125
Lumber	442,500
Merchandise, general	7,000
Pickets	30,000
Sand	1,462
Shingles	2,250
Slabs	15,000
Total	503,337

Imports:	
Apples	293
Cattle	90

Imports—Continued.	Tons.
Coal and coke	5,535
Flour	860
Hay	10,000
Lime and cement	580
Merchandise, general	6,000
Mill stuffs	10,500
Oats	128
Posts, fence	513
Salt	900
Stone	7,000
Wood	17,500
Total	59,899

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. K. Lundberg, deputy collector of customs.]

Name of harbor, Marinette, Wis.; collection district, Milwaukee, Wis.; nearest light-house, on north pier-head, Menominee, Mich.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	524	128,777	526	129,097
Sail	553	140,330	554	138,839
Total	1,077	269,107	1,080	267,936

Principal articles of export and import.

Exports:	Tons.
Coal and coke	5,100
Fish	293½
Lath	11,492½
Lumber	412,500
Paper	3,004
Pickets	6,412
Poles, telegraph	42,500
Posts, fence	9,500
Pulp	5,234
Sash, doors, and blinds	3,100
Saw logs	180,000
Shingles	12,300
Soap	300
Wood	15,000
Total	709,736

Total approximate value, $4,000,000.

Imports:	Tons.
Apples	180
Brick	600
Butter	10
Flour	75
Hay	500
Merchandise, general	100
Mill stuffs	200
Oats	256
Oil	101
Peas	2,022
Pork and beef	120
Potatoes	30
Salt	30
Saw logs	75,000
Stone	1,400
Wood	2,500
Total	83,124

I I 5.

IMPROVEMENT OF MENOMINEE RIVER, MICHIGAN AND WISCONSIN.

Object.—The formation of a channel of navigable width, 16 feet deep, from Green Bay to N. Ludington Company's mill, Marinette, Wis., a distance of about 2 miles.

Project.—The original project approved October 2, 1890, for the expenditure of $54,000 appropriated by act of September 19, 1890, was for dredging a channel 200 feet wide and 16 feet deep, from Green Bay up the Menominee River as far as available funds would admit.

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Present works.—The piers of the Menominee Harbor improvement render construction works unnecessary for the Menominee River improvement.

Depth of water.—*The lower section*, 6,550 linear feet, has been dredged 200 feet wide and 16 feet deep. The *middle section*, 2,750 linear feet, has been dredged 16 feet deep, for a width varying from 90 to 170 feet. A shoaling of from 1 to 2 feet has occurred in places since dredging was done, but there is a depth of 16 feet over the larger portion of the area dredged. The *upper section*, 2,400 linear feet, proposed width 100 feet, has a depth of from 1 to 13 feet. No work has been done upon this section.

Operations during the fiscal year.—Under contract dated December 13, 1890, with Messrs. Truman & Cooper, of Manitowoc, Wis., for dredging 200,000 cubic yards, more or less, work was in progress at the beginning of the fiscal year and continued without interruption until November 27, when dredging closed for the season. Work was resumed April 13, 1892, and is still in progress. Under this contract 126,047 cubic yards of material were removed during the fiscal year.

By hired labor and the use of United States dredges Nos. 1 and 2 78,218 cubic yards of material were removed from the channel between October 9, 1891, and June 30, 1892. Dredge No. 2 was transferred to Green Bay May 21, 1892. Dredge No. 1 was working at Menominee at the close of the fiscal year.

By hired labor and purchase of materials in open market repairs were made to the dredging plant.

Remarks and recommendations.—The formation of a channel having a uniform width of 200 feet was originally contemplated, but for reasons fully set forth in the Chief of Engineer's Report for 1891, pages 2529, 2530, it was deemed advisable to reduce the upper 2,600 linear feet to a width of 100 feet.

A comparison of the surveys made in 1889 and 1892 indicate that over the area thus far dredged considerable shoaling has occurred in places.

For the maintenance of the channel an appropriation of $10,000 is recommended.

Original estimate (see House Ex. Doc. No. 34, Fifty-first Congress, first session)	$109,609.80
Revised estimate (see Report of Chief of Engineers, 1891, pages 2529, 2530)	74,500.00

APPROPRIATIONS.

Act of—	
September 19, 1890	$54,000.00
July 13, 1892	20,500.00
Total	74,500.00

Money statement.

July 1, 1891, balance unexpended		$42,927.68
June 30, 1892, amount expended during fiscal year		27,072.69
July 1, 1892, balance unexpended		15,854.99
July 1, 1892, outstanding liabilities	$884.39	
July 1, 1892, amount covered by uncompleted contracts	8,354.05	
		9,238.44
July 1, 1892, balance available		6,616.55
Amount appropriated by act approved July 13, 1892		20,500.00
Amount available for fiscal year ending June 30, 1893		27,116.55

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Amount (estimated) required for completion of existing project*	$10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

The commercial statistics for the Menominee River are the same as for Menominee Harbor, Michigan, and Marinette, Wis.

I I 6.

IMPROVEMENT OF OCONTO HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Green Bay up the Oconto River to the city of Oconto.

Project.—The original project, adopted in 1882, provided for the formation of a channel 100 feet wide and 8 feet deep by extending the slab pier built by the city to the 10-foot contour in Green Bay, and dredging between the piers and up the river to Section Street Bridge, a distance of about 2 miles, the piers to be parallel to each other and 150 feet apart.

Present works.—(1) North pier, 1,603 feet long, 20 feet wide. For 1,100 feet the piles are 5 feet apart; for the remaining 503 feet the piles are 4 feet apart on the channel side, and 2 feet apart on the outer side, the latter being provided with wale timbers, cross-ties, and tie-rods. The filling is composed of slabs and edgings ballasted with sand. (2) South pier, 2,151 feet long, 20 feet wide. For 1,850 feet the piles are 5 feet apart; the remaining 351 feet is close piling. The filling is composed of slabs and edgings ballasted with sand, except the outer 301 feet, which is covered with 2 feet thickness of stone. (3) The outer side of the south pier, beginning 300 feet from the outer end for a distance of 1,000 feet, is protected from ice pressure by a line of close piling, thence shoreward for a distance of 850 feet by riprap. (4) Additional stability is given to 1,850 feet of the south pier by a line of piles on the channel side 3 feet apart, provided with wale timbers, cross-ties, and iron tie-rods at intervals of 9 feet.

Depth of water.—Originally 2 feet, increased to 3½ feet by local enterprise.

A plat of the soundings taken in May, 1892, shows the governing depth at the harbor entrance to be about 7½ feet, and in the river as far up as Spies Mill to be about 6½ feet.

Operations during the fiscal year.—By hired labor and purchase of materials in open market, the north pier, which was seriously damaged by a freshet in April, 1891, was repaired by driving a line of piles along the channel face for a length of 750 feet. The piles were driven 3 feet apart from center to center, and provided with wales and binders.

Remarks and recommendations.—In order to maintain a depth of 8 feet of water, periodical dredging will be necessary. The piers, being of a frail character, will require frequent repairs.

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* For maintenance of channel.

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For maintenance and preservation it is estimated that $10,000 will be needed for the fiscal year ending June 30, 1894.

Estimated cost (see Report of Chief of Engineers, 1883, page 1646)..... $150,000

APPROPRIATIONS.

Act of—	
March 3, 1881	$10,000
August 2, 1882	15,000
July 5, 1884	15.000
August 5, 1886	8,000
August 11, 1888	20,000
July 13, 1892	3,000
Total	71,000

Money statement.

July 1, 1891, balance unexpended	$2,965.13
June 30, 1892, amount expended during fiscal year	2,855.90
July 1, 1892, balance unexpended	109.23
Amount appropriated by act approved July 13, 1892	3,000.00
Amount available for fiscal year ending June 30, 1893	3,109.23
Amount (estimated) required for completion of existing project	79,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

List of material used and cost of same in place for repairing by hired labor, and purchase of materials in open market, 750 lineal feet of the north pier at Oconto, Wisconsin.

Articles and quantities.	Price.	Amount.
250 round piles, 28 feet long, furnished and driven, at	$5.00	$1,250.00
250 1½ screw bolts, nuts, and washers (3,410 pounds), at	2.63	89.68
12,192 feet B. M. pine timber, 8 inches by 12 inches	25.00	304.80
221 cords slabs and edgings for filling, at	2.25	497.25
400 cubic yards of sand ballast, at	.25	100.00
4½ days' labor leveling sand ballast, at	1.75	7.87
Total	.....	2,249.60

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. John Noonan, mayor.]

Name of harbor, Oconto, Wis.; collection district, Milwaukee, Wis.; nearest lighthouse, Sherwood Point, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	310	15,500	310	15,500
Sail	124	12,400	124	12,400
Total	434	27,900	434	27,900

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Principal articles of export and import.

Exports:	Tons.
Lath	137½
Lumber	7,500
Shingles	150
Ties, railroad	1,400
Total	9,187½
Imports:	
Apples	15
Barley	23½
Beans	30
Brick	4,000

Exports—Continued:	Tons.
Butter	¾
Coal and coke	300
Fish	50
Flour	161½
Hay	50
Lime and cement	43½
Oil	45
Sawlogs	72,000
Stone	2,800
Wood	1,000
Total	80,519

I I 7.

IMPROVEMENT OF PENSAUKEE HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Green Bay into the Pensaukee River.

Project.—The original project, adopted in 1883, provides for continuing a slab pier, which had been built by private enterprise, until it should reach the 10-foot contour in Green Bay, and dredging a channel south of it to a depth of 10 feet and width of 100 feet, connecting the deep water in the river with the deep water in the bay.

Present works.—(1) A slab pier, 1,300 feet long and 20 feet wide, filled with slabs and edgings and ballasted with sand and stone. It was built in 1883 and repaired in 1885 and 1891. (2) One thousand six hundred feet of slab pier, built by private enterprise, was nearly all destroyed by a storm in 1885. The destruction of this work left the portion of the pier built by the United States a detached work.

Depth of water.—Originally 2 feet; increased by private enterprise to from 7 to 9 feet for a width of 30 feet. The destruction of the portion of the pier built by private enterprise by the storm of October, 1885, resulted in restoring the channel to about its original condition.

A survey made in May, 1890, showed the governing depth to be 2.8 feet.

Operations during the fiscal year.—By hired labor and purchase of materials in open market, about 600 linear feet of the west end of the pier, damaged by fire in September, 1891, were repaired in October and November, 1891.

Remarks and recommendations.—For the preservation of the existing works it is estimated that $1,000 will be needed for the fiscal year ending June 30, 1894.

Should further improvement of this harbor be deemed necessary it is believed that the modified project submitted in report dated Feburary 2, 1892, the estimated cost of which is $8,800, would be all that is needed.

No arrivals or departures of vessels were reported at this harbor for the calendar year ending December 31, 1891. Several boats are engaged in fishing, and it is claimed that this business would materially increase if the water at the harbor entrance was deepened.

Estimated cost (see Report of Chief of Engineers, 1883, page 1652) $50,000

APPROPRIATIONS.

Act of—	
August 2, 1882	$10,000
July 5, 1884	5,000
Total	15,000

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Money statement.

July 1, 1891, balance unexpended	$3,731.26
June 30, 1892, amount expended during fiscal year	2,595.90
July 1, 1892, balance unexpended	1,135.36
Amount (estimated) required for completion of existing project	35,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	1,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

118.

IMPROVEMENT OF GREEN BAY HARBOR, WISCONSIN.

Object.—To secure a more direct and deeper channel from Green Bay into the mouth of the Fox River, where the harbor of Green Bay is located.

Project.—The original project, adopted in 1866, provided for dredging a channel 200 feet wide and 12 feet deep from the mouth of the Fox River, through Grassy Island, to the 12-foot contour in Green Bay, a distance of about 8,800 feet, and revetting some 650 feet of the same at Grassy Island. This project was completed in 1871.

A supplementary project adopted in 1872 provided for straightening the channel and increasing its depth to 13 feet.

In 1874 it was decided to increase the depth to 14 feet; this increased the length to about 10,600 feet.

Soundings taken through the ice in February, 1892, disclosed the existence of a shoal at a distance of 1,000 feet beyond the point to which dredging had previously been done, increasing the length of the channel to about 11,600 feet.

A modification of the existing project was submitted February 12, 1892, for increasing the depth of the present channel to 16 feet and extending it in a direct line through the bar that projects from Sable Point, making its total length about 16,500 feet.

Present works.—Revetments at Grassy Island. (1) West revetment 620 feet long and 14 feet wide, with close piling on the channel side and anchor piles about 5 feet apart on the outer side. The timber superstructure is 5 feet high. This revetment was built in 1870, rebuilt above water-line in 1887, and is in good condition. (2) East revetment 705 feet long and 14 to 17 feet wide, with close piling on the channel side, and on the bay side close piling for 425 feet, and for the remaining 280 feet piles about 5 feet apart. The timber superstructure is 7 feet high. This revetment was built in 1869, rebuilt above the water line in 1885, and is in good condition.

Depth of water.—Originally a narrow and circuitous channel 6 feet in depth. The present channel is 200 feet wide and 14 feet deep.

Operations during the fiscal year.—Under contract dated December 13, 1890, made with Messrs. White & Finch, of Grand Haven, Mich., dredging was in progress at the beginning of the fiscal year. This contract was completed September 30, 1891. The amount of material removed under this contract during the fiscal year was 15,531 cubic yards.

By hired labor and service of the United States Dredge No. 2, dredg-

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ing was begun May 24, 1892, and suspended June 20, 1892, resulting in the removal of 7,735 cubic yards of material.

Remarks and recommendations.—For continuing work on the 16-foot channel, it is estimated that $25,000 can be profitably expended during the fiscal year ending June 30, 1894, and for the preservation and maintenance of the existing works $5,000 will be needed for the same period, a total of $30,000.

Estimated cost of the project adopted in 1881 (see Report of Chief of Engineers, 1881, page 2069)	$135,000.00
Estimated cost for a channel 16 feet deep, submitted February 12, 1892.	91,915.00

APPROPRIATIONS.

Act of—		Act of—	
June 23, 1866	$30,500	March 3, 1879	$4,000
March 2, 1867	45,000	June 14, 1880	6,000
July 25, 1868 (allotted)	17,500	March 3, 1881	5,000
April 10, 1869 (allotted)	44,550	August 2, 1882	20,000
July 11, 1870	17,500	July 5, 1884	10,000
March 3, 1871	17,500	August 5, 1886	7,000
March 3, 1873	20,000	August 11, 1888	10,000
June 23, 1874	10,000	September 19, 1890	10,000
March 3, 1875	10,000	July 13, 1892	25,000
August 14, 1876	8,000		
June 18, 1878	5,000	Total	322,550

Money statement.

July 1, 1891, balance unexpended	$10,224.80
June 30, 1892, amount expended during fiscal year	6,395.75
July 1, 1892, balance unexpended	3,829.05
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	28,829.05
Amount (estimated) required for completion of existing project	71,915.00
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. Chas. Hartung, deputy collector of customs.]

Name of harbor, Green Bay, Wisconsin; collection district, Milwaukee, Wis.; nearest light house, Grassy Island, Wisconsin.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	435	157,271	431	157,535
Sail	262	49,079	271	48,545
Total	697	206,350	702	206,080

NOTE.—The figures show that a larger class of vessels than formerly is being employed in the Green Bay trade. Thus, while there were 14 less arrivals in 1891 than in 1890, the tonnage was 31,553 tons greater. There were 42 less departures in 1891 than in 1890, but the tonnage was 33,755 tons greater.

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Principal articles of export and import.

Exports:	Tons.
Barley	2,115
Beer	44½
Brick	4,478
Cattle	100
Cheese	16
Coal	2,843
Flour	21,499½
Furniture	16
Hay	118
Hogs	10
Horses	18
Iron and steel	2,115
Lime	2
Lumber	18,535½
Machinery	16
Malt	120
Merchandise, general	5,115
Mill stuffs	2,379
Oats	2,164
Oil	2
Pease	26
Pickles	31
Plaster, land	9
Potatoes	38½
Rye	2,884
Salt	269
Stone	75
Wagons and carriages	4
Wheat	1,380
Total	66,423

Imports:	Tons.
Apples	148
Barley	96
Cement	15
Coal	108,232
Fish	99
Hay	14
Horses	5
Iron and steel	8,969
Lumber	5,189
Marble	17
Merchandise, general	4,156
Oil	390
Ore, chemical	1,531
Paint	101
Salt	6,790
Sand	1,987
Sheep	4
Shingles	190
Shingle-bolts	1,066
Ties, railroad	917
Wheat	63
Wood	5,017
Wood pulp	4,786
Total	149,782

I I 9.

IMPROVEMENT OF HARBOR OF REFUGE AT ENTRANCE OF STURGEON BAY CANAL, WISCONSIN.

Object.—To form a harbor of refuge inclosing the Lake Michigan entrance to the Sturgeon Bay and Lake Michigan Ship Canal, and also to afford a safe entrance to the canal in rough weather.

Project.—The original project was submitted in 1871 and adopted in 1873. It provided for the construction of converging piers inclosing a triangular area of about 10 acres, which was to be dredged out to the requirements of navigation at that time. The piers were about 1,200 feet long, 850 feet apart at the shore line, and 250 feet at the outer end.

Supplementary projects adopted in 1879 and 1880 provided for sheet piling the pile piers, extending each pier 150 feet by detached works, so as to increase the width of entrance from 235 feet to 335 feet, and dredging to obtain at least 16 feet in depth over so much of the area of the basin as would be useful to vessels entering the harbor.

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Present works.	Width.	North pier, length.	South pier, length.
Slab pier:	*Feet.*	*Feet.*	*Feet.*
Piles 4 feet apart	14	100	100
Close piling	14	150	150
Pile pier, close piling	14	512	512
Do	18	32	32
Crib pier	20	200	200
Do	24	200	200
Length of each main pier	.....	1,194	1,194
Crib piers	24	100	100
Do	30	50	50
Length of each detached pier	.....	150	150
Total length of each pier	.....	1,344	1,344

Guide piling to connect main and detached piers, total	feet..	333
North slab and pile pier sheet piled	do...	692
South slab and pile pier sheet piled	do...	700
Material dredged	cubic yards..	153,462

The slab and pile piers were built in 1873–1874; the pile piers are in fair condition; the slab piers were rebuilt above the water line in 1889–'90. The cribs piers were built in 1878–'84, and are in fair condition. The guide piling which connects the main and detached piers, built in 1881, is considerably decayed, and will need to be reconstructed at an early date.

Depth of water.—During the month of July, 1891, a channel 120 feet wide and 16 feet deep, extending from the 16-foot contour in Lake Michigan to the entrance of canal, was completed by dredging.

A plat of soundings taken April 10, 1892, shows the governing depth on that date to be about 12 feet.

The restoration of a channel to a depth of 16 feet was begun June 21, 1892, and is in progress at the close of the fiscal year.

Operations during the fiscal year.—By hired labor and purchase of materials in open market repairs were made to the bulkheads at the outer extremities of the piers and to the sheet piling of the north and south piers.

During the months of July, 1891, and June, 1892, United States dredge No. 2 removed 13,640 cubic yards of material from the channel.

Remarks and recommendations.—The plat of soundings taken April 10, 1892, shows a deposit in the channel of about 21,000 cubic yards of material since July, 1891.

For the maintenance of the channel and piers an appropriation of $5,000 is recommended for the fiscal year ending June 30, 1894.

Estimated cost (see Report of Chief of Engineers, 1874, Part I, page 141).. $180,000

APPROPRIATIONS.

Act of—		Act of—	
March 3, 1873	$40,000	July 5, 1884	$10,000
June 23, 1874	10,000	August 5, 1886	5,000
June 18, 1878	30,000	September 19, 1890	3,000
March 3, 1879	30,000	July 13, 1892	5,000
June 14, 1880	10,000		
March 3, 1881	10,000	Total	173,000
August 2, 1882	20,000		

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Money statement.

July 1, 1891, balance unexpended	$3,025.35
June 30, 1892, amount expended during fiscal year	1,803.75
July 1, 1892, balance unexpended	1,221.60
July 1, 1892, outstanding liabilities	100.00
July 1, 1892, balance available	1,121.60
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	6,121.60
Amount (estimated) required for completion of existing project	7,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. Jesse Spalding, president Sturgeon Bay and Lake Michigan Canal and Harbor Company.]

Name of harbor, harbor of refuge at entrance of Sturgeon Bay Canal, Wisconsin; collection district, Milwaukee, Wis.; nearest light-house, on north pier head, entrance to harbor.

Arrivals and departures of vessels.

Direction.	Steam.		Sail.		Totals.	
	Trips.	Gross tons.	Trips.	Gross tons.	Trips.	Gross tons.
Down	1,608	422,600	940	335,000	2,548	757,600
Up	1,409	381,800	778	227,100	2,187	608,900
Total	3,017	804,400	1,718	562,100	4,735	1,366,500

In addition to the foregoing it is reported that 580 vessels sought shelter in the canal during the season of 1891.

I I 10.

IMPROVEMENT OF AHNAPEE HARBOR, WISCONSIN.

Object.—To secure a small artificial harbor for local purposes in the Ahnapee River with a navigable channel leading thereto from Lake Michigan.

Project.—The project of improvement adopted in 1875 provided for the formation of a small artificial harbor connected with the lake by a channel 100 feet wide and 12 feet deep, to be formed by the construction of two piers extending from the shore line to the 18 foot contour in the lake; also for blasting and dredging rock from the river bed near its mouth for a distance of 750 feet.

In accordance with a modification of the original project approved September 27, 1884, the cribs sunk in extension of the piers have been placed 50 feet farther from the center line of the channel between the piers than the old piers, and will afford, when completed, a 200-foot entrance between the pier heads.

Present works.—(1) North pier, 1,102 feet in length, composed of 352 feet of pile pier, 320 feet of which is 14 feet wide, and 32 feet, 20 feet wide; also 750 feet of cribs 20 feet wide. (2) South pier, 1,125 feet in length, composed of 625 feet of pile pier 14 feet wide, and 500 feet of

cribs 20 feet wide. The pile piers were built in 1871–1874. The south pier was provided with sheet piling in 1880 and the north pier in 1891. The superstructure is considerably decayed and will soon require renewal; in other respects both piers are in good condition. The crib piers were built in 1875 to 1889 and are in good condition.

Depth of water.—Originally 2 feet. Soundings made in October, 1891, showed a depth of water at the entrance of 16½ feet, thence to the west end of the harbor piers 12 feet.

One-third of the area from which rock has been excavated has the required depth of 12 feet; over the other two-thirds the average depth is 9 feet.

Operations during the fiscal year.—By hired labor and purchase of material in open market the north-pile pier, 352 feet long, was provided with sheet piling composed of a double row of 3-inch by 12-inch by 20-foot pine plank.

United States Dredge No. 2 removed 652 cubic yards of rock and 28,205 cubic yards of sand and gravel from the channel. The rock was used for refilling and riprapping the piers.

Remarks and recommendations.—To complete the project the following work is required: 100 linear feet of cribs for extending each pier 50 feet; 200 linear feet of guide piling to connect the main and detached piers; and the removal of about 3,500 cubic yards of rock by drilling, blasting, and dredging.

Should an appropriation be made for the fiscal year ending June 30, 1894, it is contemplated expending it chiefly for pier extension and rock removal. An appropriation of $19,000 is recommended.

The Ahnapee and Western Railroad, a new line to connect Ahnapee with the Kewaunee, Green Bay and Western Railroad at a point about midway between Kewaunee and Green Bay, is approaching completion, and it is expected will be in operation sometime during August of the present year.

Estimated cost (see Report of Chief of Engineers, 1876, Part II, pages 346–359; 1880, page 1910)	$175,000
Additional estimate (see Report of Chief of Engineers, 1891, page 2539)	10,000
Total	185,000

APPROPRIATIONS.

Act of—		Act of—	
March 3, 1871	$25,000	August 2, 1882	$12,000
June 10, 1872	25,000	July 5, 1884	15,000
March 3, 1875	25,000	August 5, 1886	15,000
August 14, 1876	8,000	August 11, 1888	5,000
June 18, 1878	8,000	September 19, 1890	6,000
March 3, 1879	7,000	July 13, 1892	7,000
June 14, 1880	7,000		
March 3, 1881	8,000	Total	173,000

Money statement.

July 1, 1891, balance unexpended	$4,726.84
June 30, 1892, amount expended during fiscal year	4,032.14
July 1, 1892, balance unexpended	694.70
Amount appropriated by act approved July 13, 1892	7,000.00
Amount available for fiscal year ending June 30, 1893	7,694.70
Amount (estimated) required for completion of existing project	12,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	12,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

List of materials used and cost of same in place for sheet piling 352 linear feet of the north pile pier at Ahnapee Harbor, Wisconsin.

44,144 feet, B. M., pine plank, at $17	$750.45
7,344 feet, B. M., pine lumber, 8 inches by 12 inches, $17	124.85
2,629 pounds screw bolts, at 2.6 cents	68.35
42,300 feet, B. M., sheet piling driven, at $10	423.00
Labor, pay rolls	327.04
1,000 pounds wrought spikes	26.80
Total	1,720.49
Cost per linear foot	4.88

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. M. T. Parker, mayor.]

Name of harbor, Ahnapee, Wis.; collection district, Milwaukee, Wis.; nearest lighthouse, Kewaunee, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	345	191,635	345	191,635
Sail	298	24,630	293	24,520
Total	643	216,265	638	216,155

Principal articles of export and import.

Exports:	Tons.
Bark, tan	1,020
Barley	210
Brick	220
Butter	95
Cattle	650
Cheese	510
Eggs	73
Fish	145
Flour	215
Furniture	10
Hay	900
Hides	27
Hogs	19
Lumber	1,100
Merchandise, general	100
Mill stuffs	95
Oats	305
Pease	3,312
Pork and beef	25
Posts, fence	2,805
Potatoes	295
Rags	22
Rye	275
Sheep	44
Shingles	770
Ties, railroad	6,710
Wheat	2,900
Wood	10,000
Wool	10
Total	32,862

Total approximate value, $480,000.

Imports:	Tons.
Agricultural implements	500
Apples	25
Beans	3
Beer and liquors	182
Cattle	25
Chairs	5
Coal and coke	160
Corn	30
Flour	538
Furniture	23
Iron and steel	70
Lath	210
Leather	32
Lime and cement	73
Lumber	2,300
Machinery, heavy	75
Marble	12
Merchandise, general	3,250
Mill stuffs	43
Oats	8
Oil	220
Pease	2
Plaster, land	170
Pork and beef	5
Provisions	465
Salt	245
Sash, doors, and blinds	13
Sheep	1
Shingles	64
Wagons, sleighs, and carriages	242
Woodenware	4
Total	8,995

Total approximate value, $410,000.

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I I 11.

IMPROVEMENT OF KEWAUNEE HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into the Kewaunee River, where the harbor of Kewaunee is situated.

Project.—The project for the improvement of this harbor was adopted in 1881, and provides for the formation of a channel from a point about 2,000 feet south of the original mouth of the Kewaunee River, through a spit of land about 300 feet wide, affording communication between the river and Lake Michigan. From the lake end of this cut two parallel piers, 200 feet apart, are to be constructed, each 1,650 feet long, extending to the 18-foot contour. Between the piers and through the cut the channel is to be dredged to a depth of 14 feet.

Present works.—Pile piers lined with sheet piling: (1) The north pier is 1,250 feet long and 16 feet wide. (2) The south pier is 1,125 feet long and 16 feet wide. They were built in 1881–1891, and are in good condition.

Depth of water.—Originally 2 feet. Soundings completed April 22, 1892, showed the governing depth of water in the entrance channel to be about 11½ feet.

Operations during the fiscal year.—Under contract dated December 13, 1890, with Mr. John M. Borgman, of Kewaunee, Wis., for the construction of 300 linear feet of pile pier; work was in progress at the beginning of the fiscal year. Under this contract the north pier was extended 250 feet and the south pier 50 feet. The work was completed September 17, 1891, and the contract closed.

Remarks and recommendations.—The conditions of this place are unusually favorable for the construction and maintenance of an excellent harbor.

The approved project provided for the construction of 3,300 linear feet of pier; of this amount 2,375 linear feet are completed.

The completion of a railroad in October, 1891, between Green Bay and Kewaunee, referred to in the last annual report, and the establishment of a line of steamers plying between Kewaunee, Wis., and Frankfort, Mich., forming a connection with existing railroad lines, a through route from the Missouri to the Atlantic seaboard has materially increased the importance of this harbor.

Two steamers for the carriage of 24 cars each between Kewaunee and Frankfort are now under construction, to be completed and delivered September 1. They are 256 feet over all, 54 feet beam, and are expected to draw 12 feet of water.

Should an appropriation be made for the fiscal year ending June 30, 1894, it is contemplated to expend it chiefly in pier construction. An appropriation of $75,000 is recommended.

Estimated cost (see Report of Chief of Engineers, 1881, page 2084) $200,000

APPROPRIATIONS.

Act of—	
March 3, 1881	$5,000
August 2, 1882	12,000
July 5, 1884	18,000
August 5, 1886	10,000
August 11, 1888	10,000
September 19, 1890	20,000
July 13, 1892	30,000
Total	105,000
.ppropriated by the local authorities in 1881, and expended by the United States under the direction of the engineer officer in charge	8,042.72

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Money statement.

July 1, 1891, balance unexpended	$11,080.46
June 30, 1892, amount expended during fiscal year	10,736.79
July 1, 1892, balance unexpended	343.67
Amount appropriated by act approved July 13, 1892	30,000.00
Amount available for fiscal year ending June 30, 1893	30,343.67
Amount (estimated) required for completion of existing project	86,957.28
Amount that can be profitably expended in fiscal year ending June 30, 1894	75,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

List of materials used and cost of same in place for the construction of 250 linear feet of the north pier and 50 linear feet of the south pier, at Kewaunee Harbor, Wisconsin, under contract with Mr. John M. Borgman, dated December 13, 1890.

Articles.	Quantities.	Price.	Amount.
Round piles furnished and driven ..... linear feet	15,409	$0.20	$3,081.80
Pine timber, 6 inches by 12 inches ..... do	627	.13	81.51
Pine timber, 12 inches by 12 inches ..... do	546	.23	125.58
White oak timber, 6 inches by 12 inches, and 10 inches by 12 inches ..... feet, B. M.	20,292	47.50	963.87
Pine sheet pile plank, 3 inches by 12 inches by 28 feet, furnished and driven ..... feet, B. M.	50,832	29.00	1,474.13
Pine plank, 3 inches by 12 inches by 16 feet, furnished and laid ..... feet, B. M.	4,236	14.00	59.30
Screw bolts and tie rods ..... pounds	8,831	.04½	397.39
Wrought iron spikes ..... do	1,096	.04	43.84
Stone ..... cords	728.3	4.65	3,386.59
Total			9,614.01
Cost per linear foot			32.05

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Hon. John Wattawa, mayor.]

Name of harbor, Kewaunee, Wis.; collection district, Milwaukee, Wis.; nearest light-house, on north pier head, Kewaunee, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	401	221,522	401	221,522
Sail	213	13,423	213	13,423
Total	614	234,945	614	234,945

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Principal articles of export and import.

Exports:	Tons.
Bark, tan	1,320
Barley	235
Brick	2,000
Butter	90
Cattle	240
Cheese	250
Eggs	30
Fish	45
Flour	16,125
Hay	1,000
Hides	7½
Hogs	50
Iron and steel	25
Lumber	150
Merchandise, general	1,500
Mill stuffs	3,200
Pease	3,750
Plaster, land	100
Pork and beef	12
Posts, fence	1,425
Potatoes	60
Rye	70
Salt	1,200
Stone	7,000
Ties, railroad	4,900
Wheat	1,500
Wood	13,000
Wool	1½
Total	59,286

Total approximate value, $1,200,000.

Imports:	Tons.
Apples	75
Beer	179½
Chairs	9
Coal and coke	250
Flour	13,975
Iron and steel	200
Lath	14
Leather	12
Lime and cement	145
Lumber	600
Malt	237½
Merchandise, general	3,200
Oil	180
Pork and beef	24
Salt	1,620
Sash, doors, and blinds	10
Shingles	45
Wagons and carriages	12½
Wooden ware	1¾
Total	20,790¼

Total approximate value, $850,000.

I I 12.

IMPROVEMENT OF TWO RIVERS HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into Twin Rivers, where the harbor of Two Rivers is situated.

Project.—The project for the improvement of this harbor, adopted in 1870, provided for the construction of two parallel piers extending from the river mouth to the 18-foot contour in Lake Michigan, and dredging between them to a depth of 12 feet.

Present works.—Pile and crib piers: (1) North pier, 1,810 feet long, composed of 1,060 feet of pile pier 14 feet wide and 750 feet of cribs 20 feet wide. (2) South pier, 1,710 feet long, composed of 960 feet of pile pier 14 feet wide and 750 feet of cribs 20 feet wide. The pile piers were built in 1871–1874, and the cribs in 1875–1884. The latter are in good condition. The timber superstructure of the pile piers is much decayed and should be rebuilt at an early day.

Depth of water.—Originally from 2 to 3 feet. In November, 1890, a channel 90 feet wide and 12 feet deep was completed. A survey completed May 4, 1892, showed the existence of a channel about 50 feet wide and 9½ feet deep.

Operations during the fiscal year.—There were no operations during the fiscal year ending June 30, 1892.

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Remarks and recommendations.—The steam tugs at this harbor are employed in the fishing trade and towage of rafts from the northern end of Lake Michigan and Green Bay, therefore they are not available for towing sailing vessels seeking entrance into the harbor; hence when the wind is unfavorable they are obliged to "beat" in. Water being shoal near the shore ends of the harbor piers, they sometimes touch bottom when well inside the harbor entrance. It will therefore be desirable to dredge the channel 12 feet deep the full width between the piers. This would require the removal of about 39,000 cubic yards of material.

For the formation of a wider channel, maintenance of the same, and rebuilding decayed superstructure, an appropriation of $12,000 is recommended for the fiscal year ending Jule 30, 1894.

Estimated cost (see Report of Chief of Engineers, 1871, page 123)..... $265,588.80

APPROPRIATIONS.

Act of—		Act of—	
March 3, 1871	$25,000	March 3, 1881	$15,000
June 10, 1872	25,000	August 2, 1882	15,000
March 3, 1873	25,000	July 5, 1884	8,000
June 23, 1874	15,000	August 11, 1888	2,500
March 3, 1875	15,000	September 19, 1890	3,000
August 14, 1876	5,000	July 13, 1892	3,000
June 18, 1878	10,000		
March 3, 1879	20,000	Total	206,000
June 14, 1880	20,000		

Money statement.

July 1, 1891, balance unexpended	$860.98
June 30, 1892, amount expended during fiscal year	261.12
July 1, 1892, balance unexpended	599.86
Amount appropriated by act approved July 13, 1892	3,000.00
Amount available for fiscal year ending June 30, 1893	3,599.86
Amount (estimated) required for completion of existing project	59,088.80
Amount that can be profitably expended in fiscal year ending June 30, 1894	12,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. R. E. Mueller, mayor.]

Name of harbor, Two Rivers, Wis.; collection district, Milwaukee, Wis.; nearest light-house, on north pier head, Two Rivers, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Steam	253	27,405	253	27,405
Sail	63	16,523	63	16,523
Total	316	43,928	316	43,928

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Principal articles of export and import.

Exports:	Tons.
Apples	50¾
Barley	136¾
Beer	910
Butter	14
Cattle	258
Chairs	9,000
Cheese	43½
Eggs	18
Fish	900
Flour	1,505
Furniture	13,500
Hay	3,600
Hides	35½
Hogs	73
Iron and steel	80
Leather	1¼
Lumber	5,550
Merchandise, general	1,850
Mill stuffs	700
Oats	48
Pease	336
Poles, telegraph	340
Posts, fence	57
Potatoes	660
Provisions	13
Rye	218½
Saw logs	660
Sheep	68
Shingles	75
Wagons and carriages	55
Wheat	1,461
Woodenware	17,848½
Wool	4
Total	60,069½

Total approximate value, $2,600,000.

Imports:	
Agricultural implements	80
Apples	117
Barley	141

Imports—Continued.	Tons.
Beans	16¾
Beer	455
Butter	1½
Brick	9,400
Cattle	486
Chairs	45
Cheese	3½
Coal and coke	13
Corn	1,288
Fish	21
Flour	408½
Furniture	236½
Hay	8,200
Hides	37
Hogs	112
Iron and steel	730
Lath	1,375
Leather	8½
Lime and cement	493
Lumber	8,700
Malt	12
Marble	20
Merchandise, general	6,800
Mill stuffs	560
Oats	448
Oil	1,890
Plaster, land	1,200
Pork and beef	76¾
Potatoes	138
Provisions	13½
Rye	120½
Salt	675
Sash, doors, and blinds	780
Saw logs	78,000
Shingles	1,410
Stone	8,820
Ties, railroad	224
Wagons and carriages	50
Wood	11,500
Total	145,105½

Total approximate value, $3,550,000.

I I 13.

IMPROVEMENT OF MANITOWOC HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into the Manitowoc River, where the harbor of Manitowoc is situated.

Project.—The original project, adopted in 1852, provided for the construction of two parallel crib piers, 220 feet apart, extending from the mouth of the Manitowoc River to the 12-foot contour in Lake Michigan. It was completed in 1871. In 1881, to meet the increased demands of commerce, a project was adopted for extending the piers to the 18½-foot contour and obtaining a channel of not less than 14 feet depth at the shore line, increasing to 18 feet at the entrance. Pier extension under this project was completed in 1887, and the dredging in 1889.

In 1890 a project for an exterior breakwater 400 feet long was submitted.

Present works.—Crib piers: (1) North pier, 1,970 feet long, composed of 1,220 feet of cribs 20 feet wide and 750 feet 24 feet wide; (2) South

pier, 1,900 feet long, composed of 1,150 feet of cribs 20 feet wide and 750 feet 24 feet wide.

Depth of water.—Originally 3 feet. A survey completed April 29, 1892, showed a depth of water at the entrance of 16½ feet, and a channel of navigable width situated midway between the piers about 14½ feet deep.

Operations during the fiscal year.—Under contract dated December 13, 1890, with Messrs. Truman & Cooper, of Manitowoc, Wis., for rebuilding above the water line 600 linear feet, more or less, of the north pier, work was begun May 26, 1891. Three hundred and forty-two linear feet of pier were rebuilt during the fiscal year, making the total number of feet rebuilt under this contract 742. The work was completed July 31, 1891, and the contract closed.

Under a special agreement made April 23, 1891, with Messrs. Truman & Cooper, of Manitowoc, Wis., 2,429 cubic yards of material were removed from the channel by dredging during the fiscal year. The total number of cubic yards of material removed under this agreement was 11,894. The dredging was completed July 16, 1891.

Remarks and recommendations.—The north pier was completed in 1885, the south pier in 1887, and the dredging in 1889.

About 900 feet of the inshore superstructure is twenty years old or more. It is badly decayed, and should be rebuilt above the water line without delay.

For the preservation of the piers and maintenance of the channel an appropriation of $12,000 is recommended for the fiscal year ending June 30, 1894, and for an exterior breakwater an appropriation of $40,000 is recommended.

Estimated cost (see Report of Chief of Engineers, 1881, page 2094)	$308,182.54
Additional estimate for a breakwater (see Report of Chief of Engineers, 1890, page 2345)	40,000.00
Total	348,182.54

APPROPRIATIONS.

Act of—		Act of—	
August 30, 1852	$8,000	March 3, 1879	$6,500
June 23, 1866	52,000	June 14, 1880	7,000
March 2, 1867	45,000	March 3, 1881	4,000
July 25, 1868 (allotted)	17,500	August 2, 1882	10,000
April 10, 1869 (allotted)	17,820	July 5, 1884	15,000
July 11, 1870	20,000	August 5, 1886	15,000
March 3, 1871	11,000	August 11, 1888	8,000
March 3, 1873	20,000	September 19, 1890	8,000
June 23, 1874	10,000	July 13, 1892	28,000
March 3, 1875	10,000		
August 14, 1876	8,000	Total	335,820
June 18, 1878	15,000		

Money statement.

July 1, 1891, balance unexpended (correct amount, Report 1891)	$5,120.72
June 30, 1892, amount expended during fiscal year	4,260.97
July 1, 1892, balance unexpended	859.75
Amount appropriated by act approved July 13, 1892	28,000.00
Amount available for fiscal year ending June 30, 1893	28,859.75
Amount (estimated) required for completion of existing project*	24,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	24,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

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* Including $12,000 for preservation of piers and maintenance of channel.

List of materials used and cost of same in place under contract dated December 13, 1890, with Horatio Truman and George Cooper, of Manitowoc, Wis., for rebuilding above the water line 742 linear feet of the north pier at Manitowoc Harbor, Wisconsin.

Articles.	Quantity.	Price.	Amount.
Pine timber, 12 by 12 inches ..... feet B. M..	145,572	$27.00	$3,980.44
Pine plank, 3 by 12 inches ..... do....	7,890	19.00	149.91
Drift bolts ..... pounds..	8,628	.03½	301.98
Spikes ..... do....	335	.04	13.40
Stone ..... cords..	34	6.00	204.00
Total	.....	.....	4,599.73

Cost per linear foot $6.20

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. Frederick Schuette, mayor.]

Name of harbor, Manitowoc, Wis.; collection district, Milwaukee, Wis.; nearest light-house, Manitowoc, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	778	490,073	781	489,278
Sail	260	57,395	259	56,858
Total	1,038	547,468	1,040	546,136

Principal articles of export and import (harbor only).

Exports:	Tons.
Agricultural implements...	250
Barley	47
Beer	175
Brick	1,200
Butter	82½
Cattle	30
Cheese	2,130
Eggs	93¾
Flour	39,664½
Furniture	1,000
Hay	1,200
Hides	25
Leather	375
Lumber	5,250
Merchandise (general)....	2,500
Millstuffs	6,750
Oats	1,128
Pease	7,510
Pork and beef	42
Potatoes and vegetables ...	870
Rye	126
Shingles	75
Ties (railroad)	245

Exports—Continued.	Tons.
Wagons and carriages	225
Wheat	1,071
Wool	5
Total	72,069¾

Imports:	
Agricultural implements...	17½
Coal and coke	129,380
Iron and steel	502½
Lath	185¾
Leather	46¾
Lime and cement	145
Lumber	6,000
Merchandise (general).....	20,000
Plaster, land	600
Salt	2,670
Saw logs	13,500
Stone	3,500
Wood	10,000
Total	186,547½

Total approximate value of exports, $3,250,000; total approximate value of imports, $2,750,000.

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I I 14.

IMPROVEMENT OF SHEBOYGAN HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into the Sheboygan River, where the harbor of Sheboygan is situated.

Project.—The project for the improvement of this harbor was adopted in 1852, and had for its object the formation of a 12-foot channel entrance to the mouth of the Sheboygan River. This was modified in 1873 so as to secure a deeper channel by farther pier extension and dredging. Both projects were completed within their estimated cost, and a channel was formed 100 feet wide, with a depth of 15 to 16 feet between the piers. A survey made in 1880 showed a depth of less than 12 feet between the piers and on the outer bar. The existing project was adopted in 1881, its object being to deepen the channel still further by extending the piers to the 20-foot contour in the lake and dredging to a depth of 18 feet between their outer ends, the depth decreasing to 14 feet at the shore line.

Present works.—Pile and crib piers: (1) North pier, 2,270 feet long, composed of 900 feet of pile and crib pier, built by the city, from 12 to 20 feet wide; 1,320 feet of cribs 20 feet wide, and 50 feet of cribs 30 feet wide. (2) South pier, 2,387 feet long, composed of 780 feet of pile and crib pier, built by the city, from 12 to 20 feet wide; 132 feet of pile pier 20 feet wide, 1,425 feet of cribs 20 feet wide, and 50 feet of cribs 30 feet wide; built 1852–'91. About 850 feet of the north pier and 900 feet of the south pier built, since 1871, are in good condition, the cribs having been sunk on a stone or pile foundation. Previous to 1871 they were sunk on the natural lake bottom, composed of shifting sand, causing them to settle very unevenly.

Depth of water.—Originally 4 feet. A survey completed April 26, 1892, showed the governing depth of water in the channel on that date to be about 13.7 feet.

Operations during the fiscal year.—Under contract dated December 13, 1890, with Messrs. Truman and Cooper, of Manitowoc, the north pier was extended 150 feet by the construction of three cribs, each 50 feet long, 20 feet wide, and 20½ feet high, including superstructure. These cribs were sunk upon foundations consisting of 24 piles for each crib, cut off 13½ feet below the established datum plane. Work under this contract was completed October 20, 1891.

Dredging by hired labor and the use of United States Dredge No. 1, for the improvement of the channel, was begun June 26, 1891, and in progress at the beginning of the fiscal year. It was continued until August 15, 1891, when the work was closed and the dredge transferred to Port Washington. The dredging resulted in the formation of a channel 16 feet deep with a width of 90 feet for about two-thirds of its length and 60 feet wide for the remainder; 17,030 cubic yards of material were removed during the fiscal year.

Remarks and recommendations.—A channel of less than 16 feet does not meet the present requirements of the commerce of this harbor. Its reduction in depth to less than 14 feet this season, with no funds available for dredging, has been the source of much annoyance and caused serious loss to shippers and others interested in navigation.

Several vessels laden with coal for this port, after vainly attempting to enter the harbor, have been obliged to seek other ports to discharge their cargoes; and steamers plying the west shore of Lake Michigan, and advertising to stop here daily, have been obliged to pass in heavy

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weather without stopping, thereby causing serious loss and great annoyance to owners of vessels, shippers, consignees, passengers, and many others more or less concerned.

Should an appropriation be made for the fiscal year ending June 30, 1894, it is proposed to expend it in pier extension and such dredging and repairs as may be necessary for the maintenance of the channel and piers. An appropriation of $67,000 is recommended.

Estimated cost of the present project, adopted in 1881 (see Report of Chief of Engineers, 1881, page 2104)	$150,000
Additional estimate (see Report of Chief of Engineers, 1884, page 1856)	45,000
Total	195,000

APPROPRIATIONS.

Act of—		Act of—	
August 30, 1852	$10,000.00	June 18, 1878	$4,000.00
June 28, 1864 (allotted)	10,000.00	March 3, 1879	3,000.00
June 23, 1866	47,598.91	June 14, 1880	7,000.00
March 2, 1867	8,000.00	March 3, 1881	25,000.00
April 10, 1869 (allotted)	14,850.00	August 2, 1882	30,000.00
July 11, 1870	15,000.00	July 5, 1884	28,000.00
March 3, 1871	15,000.00	August 5, 1886	15,000.00
June 10, 1872	18,000.00	August 11, 1888	15,000.00
March 3, 1873	10,000.00	September 19, 1890	15,000.00
June 23, 1874	10,000.00	July 13, 1892	25,000.00
March 3, 1875	12,000.00		
August 14, 1876	6,000.00	Total	343,448.91

Money statement.

July 1, 1891, balance unexpended	$12,525.43
June 30, 1892, amount expended during fiscal year	12,392.75
July 1, 1892, balance unexpended	132.68
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	25,132.68
Amount (estimated) required for completion of existing project	42,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	42,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

List of materials used and cost of same in place for extending the north pier 150 feet by 3 cribs, each 50 by 20 by 20½ feet, at Sheboygan Harbor, Wis., under contract dated December 13, 1890, with Horatio Truman and George Cooper, of Manitowoc, Wis.

Articles.	Quantity.	Price.	Amount.
Pine timber, 12 by 12 inches and 12 by 18 inches ... feet B. M.	98,856	$25.00	$2,471.40
Hemlock timber, 12 by 12 inches and 12 by 18 inches ... do	92,952	22.00	2,044.94
Pine plank, 3 by 12 inches ... do	9,240	18.00	166.32
Foundation piles ... number	72	11.50	828.00
Iron drift bolts ... pounds	12,685	.03	380.55
Iron screw bolts ... do	3,694 3/10	.04	147.77
Wrought iron spikes ... do	282	.04	11.28
Stone ... cords	636 1/10	6.50	4,134.65
Total			10,184.91

Cost per linear foot, $67.90.

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COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Col. J. A. Watrous, collector of customs, Milwaukee, Wis., and Mr. John M. Kohler, mayor of Sheboygan, Wis.]

Name of harbor, Sheboygan, Wis.; collection district, Milwaukee, Wis.; nearest light-house, Sheboygan, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	554	445,548	528	469,296
Sail	616		631	
Total	1,170	445,548	1,159	469,296

Principal articles of export and import.

Exports:	Tons.	Imports:	Tons.
Beer	2,100	Bark (tan)	10,080
Boots and shoes	1,150	Coal and coke	62,000
Chairs	8,000	Empty bottles	2,200
Cheese	5,000	Glue	100
Coal and coke	35,000	Hay and grain	1,500
Eggs	180	Hides	400
Fish	450	Lime and cement	4,834
Flour	2,500	Lumber and lath	162,500
Furniture	14,000	Merchandise (general)	10,500
Hay	456	Oil and varnish	2,000
Hollow ware	3,100	Pig iron	3,000
Leather	2,000	Plaster (land)	1,580
Lime and stone	1,200	Posts (fence) and ties	1,305
Machinery	300	Salt	1,250
Mineral water	1,200	Shingles	370
Pease	500	Wines and liquors	162¼
Salt	750	Wood and slabs	16,000
Wooden ware	750	Veneering	2,000
Veneering	2,000		
Total	80,636	Total	281,781¼
Total approximate value	$8,130,350	Total approximate value	$4,950,160

I I 15.

IMPROVEMENT OF PORT WASHINGTON HARBOR, WISCONSIN.

Object.—To secure a navigable channel entrance from Lake Michigan to a small artificial harbor formed by excavating two interior connected basins.

Project.—The original project for the improvement of this harbor was adopted in 1869, and provided for the building of two parallel piers extending from the shore line to 10 feet of water in the lake, and the excavation of a basin 600 feet long by 200 feet wide inside of the shore line. In 1870 a deflection of about 10 degrees to the southward was made in the direction of the piers, this being considered a more favorable direction for their alignment. In 1876 a further modification of the plan was made by excavating a second basin to the northward and nearly at right angles to the first basin, and extending the piers to the 14-foot contour in the lake. This doubled the available area of the harbor and reduced the height of the entering waves very materially.

This is the project now being carried out. The two interior basins have a combined area of about 5¾ acres and area to be dredged to a

depth of 12 feet, with a channel of the same depth connecting them with the lake, the channel inclosed between two piers 150 feet apart and extending out to 14 feet of water.

Present works.—(1) North pier, 920 feet long, composed of 370 feet of cribs 14 feet wide; 500 feet, 20 feet wide, and 50 feet, 24 feet wide. (2) South pier 1,226 feet long, composed of 370 feet of cribs 14 feet wide; 450 feet 20 feet wide, and 406 feet of pile revetment. The piers were built 1871–1887, and are in good condition, with the exception of 640 linear feet of superstructure, built in 1871, which is much decayed and requires renewal.

Depth of water.—The original depth of water at the mouth of Sauk River was about one foot. Soundings taken in May, 1892, indicated a ruling depth in the entrance channel of 10½ feet.

Operations during the fiscal year.—By hired labor and the use of United States Dredge No. 2, 14,360 cubic yards of material were removed from the entrance channel and basins. Dredging was suspended October 15, 1891, and the dredge transferred to Menomonee, Mich. About 40 cords of stone were transferred from the shore end of the piers to the pier heads and used for refilling and riprap where undue settlement had occurred.

Remarks and recommendations.—The north pier was built the full length contemplated in 1887. It is proposed to complete the south pier by extending it 100 feet as soon as funds are appropriated.

From September, 1890, to May, 1892, there was a deposit in the channel and basins of about 7,000 cubic yards of material, reducing the depth of water in the entrance channel about 1½ feet. The removal of about 13,000 cubic yards of material is necessary to maintain the required depth of water in the channel and basins. Three hundred and twenty linear feet of the shore end of each pier, built in 1871, have seen twenty-one years' service. The superstructure of this portion of the piers is badly decayed and should be rebuilt above the water line. The estimated cost of the dredging and rebuilding 640 linear feet of superstructure is $10,000.

Should an appropriation be made for the fiscal year ending June 30, 1894, it is contemplated to expend it for dredging, and rebuilding above the water line the shore ends of the north and south piers. An appropriation of $16,500 is recommended.

APPROPRIATIONS.

Act of—		Act of—	
July 11, 1870	$15,000	March 3, 1881	$17,000
March 3, 1871	15,000	August 2, 1882	17,000
June 10, 1872	15,000	July 5, 1884	10,000
March 3, 1873	15,000	August 5, 1886	5,000
June 23, 1874	10,000	August 11, 1888	5,000
March 3, 1875	10,000	September 19, 1890	3,000
August 14, 1876	8,000	July 13, 1892	6,500
June 18, 1878	5,000		
March 3, 1879	7,500	Total	184,000
June 14, 1880	20,000		

Money statement.

July 1, 1891, balance unexpended	$3,034.70
June 30, 1892, amount expended during fiscal year	2,901.34
July 1, 1892, balance unexpended	133.36
Amount appropriated by act approved July 13, 1892	6,500.00
Amount available for fiscal year ending June 30, 1893	6,633.36

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Amount (estimated) required for completion of existing project*	$10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. James McCarthy, harbor master.]

Name of harbor, Port Washington, Wis.; collection district, Milwaukee, Wis.; nearest light-house, on outer end of north harbor pier, Port Washington, Wis.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	39	3,510	39	3,510
Sail	152	11,730	152	11,730
Total	191	15,240	191	15,240

Principal articles of export and import.

Exports:	Tons.
Apples	22
Barley	282
Beans	15
Beer	180
Brick	2,600
Butter	75
Chairs	350
Cheese	80
Corn	280
Eggs	131
Flour	1,935
Furniture	337
Hay	100
Hogs	13
Lath	96
Leather	315
Lumber	3,900
Malt	550
Merchandise (general)	900
Mill stuffs	725
Oats	192
Pease	105
Pork and beef	4
Potatoes	540
Provisions	30
Shingles	375
Wheat	300
Woodenware	77
Total	14,509
Total approximate value	$631,750

Imports:	Tons.
Apples	45
Bark (tan)	1,540
Barley	2,703
Beans	18
Beer	26
Butter	3
Cheese	2
Coal and coke	1,600
Flour	54
Hay	250
Hides	725
Iron and steel	700
Lath	110
Leather	3
Lime and cement	218
Lumber	7,000
Merchandise (general)	14,000
Mill stuffs	50
Oats	80
Oil	315
Plaster (land)	20
Pork and beef	22
Posts (fence)	95
Potatoes	21
Provisions	90
Rye	84
Salt	750
Sash, doors, and blinds	35
Saw logs	1,800
Shingles	450
Stone	448
Wagons and carriages	6
Wheat	135
Wood	3,750
Total	37,148
Total approximate value	$716,318

* For repairs and dredging.

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I I 16.

HARBOR OF REFUGE AT MILWAUKEE BAY, WISCONSIN.

Object.—To provide a secure anchorage for vessels engaged in the general commerce of the lakes, by inclosing the northern section of Milwaukee Bay within a breakwater, formed of timber crib work, placed and sunk upon a foundation of stone.

Project.—The project was adopted in 1881 and provided for the construction of a breakwater, the north arm of which commences at a distance of about 600 feet from the north shore of the bay, in a depth of 8 feet of water.

Its direction is S. 25° 19′ E. and its length 2,450 feet. From this point the direction of the main arm of the breakwater is changed to S. 11° W. for the proposed distance of 5,200 feet, with an opening of 400 feet at the distance of 1,000 feet from the angle, to provide a fair-weather entrance and exit for vessels.

Present works.—The north arm of the breakwater is completed. The most northerly section of it, 600 feet in length, is comprised of 6 cribs, each 100 feet long and 20 feet wide, and the remaining 1,850 feet of 37 cribs, each 50 feet long by 24 feet wide.

The dimensions of the cribs forming the main arm to the northward of the opening are 50 feet by 24 feet by 22½ feet, with the exception of crib No. 62, which is next to or immediately northward of the opening and is 100 feet long by 24 feet wide by 22½ feet high, over the whole of which superstructure has been built to a height of 6 feet above datum.

Seven cribs, numbered from 63 to 69 inclusive, each of dimensions 100 by 24 by 22½ feet, have been sunk to the southward of the opening, over 400 feet of which superstructure has been built.

The total length of substructure built is 4,150 feet, upon which 3,850 feet of superstructure has been built.

Depth of water.—The slope of the lake bed from the northern end of the breakwater to the angle formed by the north and main arms is 0.87 feet to 100 feet, the angle crib being set in 29.4 feet of water. The average depth of water on the line of section of main arm to the southward of the opening is 34.6 feet.

Operations during the fiscal year.—Under the contract made with Christopher H. Starke, dated December 13, 1890, Crib No. 62 was sunk to the northward of the opening for fair-weather exit, and Crib No. 66′ was built to a height of 18½ feet and sunk upon the foundation upon which the overturned Crib No. 66 was first placed. Cribs Nos. 67, 68, and 69 were built and sunk in their respective positions and covered with a decking of plank of 4 inches in thickness and 8 inches in width, the apertures between planks being about 1½ inches wide. A similar decking of plank was spiked on the superstructure built under this contract over Cribs Nos. 63, 64, 65, and 66 to a height of 6 feet above datum, the length of the substructure under the contract being 500 feet and of superstructure 525 feet.

The scow *Dunham* has been reëngaged to serve as light-ship at the south end of the breakwater, under a new agreement made with her owner, in accordance with the terms of advertisement and sepecifications.

Remarks and recommendations.—On the 13th of May last soundings were taken around cribs Nos. 62 to 69 inclusive, a plat of which shows that but very slight changes have been made in their foundations during the past winter. The superstructure has suffered no material dam-

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age, either from sea or ice, which is evidence that no storms of unusual severity have occurred.

The shore accretions which have formed in the northern section of the harbor are large, their superficial area being now about 15 acres in extent. The anchorage area outside of the contour line of 18 feet is somewhat diminished. The project adopted by the Board of Engineers, constituted by Special Orders No. 32, paragraph 2, Headquarters Corps of Engineers, dated April 7, 1881, was as follows:

Starting from near North Point, in 8 feet of water, but leaving a gap of about 600 feet between the beginning of the breakwater and the shore, to be closed hereafter if found necessary, etc.

From the rapidity with which the shore accretions have formed, it is now considered desirable to close the space between the northern end of the breakwater and the shore, leaving an opening of about 50 feet at the present end of the breakwater for the passage and accommodation of small boats. A row of sheet piling, reënforced by main piles and binders, would effect this, at a cost not exceeding $12 per running foot, or a total expenditure of about $6,240.

APPROPRIATIONS.

Act of—		
March 3, 1881		$100,000.00
August 2, 1882		100,000.00
July 5, 1884		85,000.00
August 5, 1886	$60,000.00	
From which allotted to Milwaukee harbor	4,737.91	
		55,262.09
August 11, 1888		70,000.00
September 19, 1890		80,000.00
July 13, 1892		75,000.00
Total		565,262.09

Money statement.

July 1, 1891, balance unexpended	$81,078.76
June 30, 1892, amount expended during fiscal year	65,022.71
July 1, 1892, balance unexpended	16,056.05
Amount appropriated by act approved July 13, 1892	75,000.00
Amount available for fiscal year ending June 30, 1893	91,056.05
Amount (estimated) required for completion of existing project	234,739.91
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

Name of harbor, Harbor of Refuge at Milwaukee Bay, Wisconsin; collection district, Milwaukee, Wis.; nearest port of entry, Milwaukee, Wis.; amount of revenue collected at nearest port of entry, $365,922.16.

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I I 17.

IMPROVEMENT OF MILWAUKEE HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into the Milwaukee River, which is the interior harbor of Milwaukee.

Project.—The original project adopted in 1852 provided for the formation of a channel 260 feet wide and 12 feet deep, by dredging across the point which overlapped the mouth of the Milwaukee River at the distance of 3,000 feet to the northward of its original outlet, and by the construction of parallel piers of crib work, each 1,120 feet in length, for the protection of the sides of the channel thus formed. In 1868 an extension of the piers became necessary for the requirements of commerce, and under a continuation of the original project both the north and south piers were extended 600 feet into the lake to 18 feet depth of water.

Present works.—The entire length of the channel between the piers is 1,740 feet; its width at the outer end has been increased through the outward settling of cribs to 284 feet.

The width of each of the 1,120-foot sections of piers first built is 20 feet. The pier extensions of 600 feet in length are 26 feet wide, excepting the pier heads, which are each 30 feet wide and 50 feet long, protected by a bulkhead of piles and oak timbers.

The superstructure of the inner section of the north pier for 1,052.6 feet of its length by 20 feet in width, is of quarry-faced dry stone masonry, the side walls being 4 feet thick. Between these walls for a length of 663 feet the filling is of stone packed with gravel, and covered with large paving stones of 9 inches in thickness. The filling between walls for the remaining 389.6 feet is of packed stone, with a top layer of concrete pavement of 9 inches in thickness. Piles for the protection of the piers have been driven along the channel faces. The superstructure over the pier extensions of the 600 feet was built in 1871 and 1872. In 1887 the superstructure of the 600 feet extension of the north pier was cut down and rebuilt. In 1889 the superstructure of 400 feet of the outer section of the south pier was cut down and rebuilt.

Depth of water.—Soundings were taken between the piers and in Lake Michigan beyond the extremities of piers on the 4th day of May, 1892, a plat of which shows that since similar soundings were taken in November, 1891, a deposit of about 0.8 feet of material has been made in the channel between piers, leaving a depth of waterway of 17 feet. Outside of the pier extremities the water is fully 18 feet deep below the datum plane.

Operations during the fiscal year.—Proposals were opened on the 15th day of July, 1891, for dredging the channel between the piers to a depth of 18 feet and for a width of 162 feet. Mr. Christopher H. Starke's bid for doing the work at 18 cents per cubic yard was the lowest offer received, and a contract was made with him on July 29, 1891, under which 25,896 cubic yards of material were removed from the channel. Ten and three-fourths cords of stone were purchased and placed in the north pier in places where the concrete covering had been removed by the waves.

Remarks and recommendations.—In the report of June 30, 1889, the needs of this harbor were stated in detail. The deterioration of the piers from wear and climate has been steadily progressing since that time. In 1879 it was estimated that an average yearly expenditure of $10,000 would be required for the maintenance of this harbor. Since

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that time the average yearly expenditure has been but $4,218.30, or a total of the sums appropriated in thirteen years of $54,837.91.

APPROPRIATIONS.

Expended on former mouth of Milwaukee River:	
Act of—	
July 4, 1836	$400.00
March 3, 1843	30,000.00
June 11, 1844	20,000.00
Straight cut:	
August 30, 1852	15,000.00
March 3, 1853	163.94
June 23, 1866	48,283.51
April 10, 1869 (allotted)	35,640.00
July 11, 1870	40,000.00
March 3, 1871	38,000.00
March 3, 1873	10,000.00
June 23, 1874	10,000.00
March 3, 1875	25,000.00
August 14, 1876	26,000.00
June 18, 1878	15,000.00
March 3, 1879	7,500.00
June 14, 1880	10,000.00
March 3, 1881	8,000.00
August 2, 1882	10,000.00
August 5, 1886 (from appropriation for harbor of refuge)	4,737.91
August 11, 1888	10,000.00
March 17, 1890 (special act)	6,100.00
September 19, 1890	6,000.00
July 13, 1892	14,000.00
Total expenditure at Straight Cut	339,425.36
Expended at former mouth of Milwaukee River	50,400.00
Total expended at Straight Cut and old river mouth	389,825.36

Money statement.

July 1, 1891, balance unexpended	$6,550.13
June 30, 1892, amount expended during fiscal year	5,752.62
July 1, 1892, balance unexpended	797.51
Amount appropriated by act approved June 13, 1892	14,000.00
Amount available for fiscal year ending June 30, 1893	14,797.51

Improving harbor at Milwaukee, Wis. Abstract of proposals for dredging about 26,000 cubic yards of material, received in response to advertisement dated June 19, 1891, and opened July 15, 1891.

Amount appropriated available for this work, $5,000.

No.	Name and address of bidder.	Price per cubic yard.
		Cents.
1	Samuel O. Dixon, Racine, Wis	20
2	Green Bay Dredge and Pile Driver Company, Green Bay, Wis	22½
3	Christopher H. Starke, Milwaukee, Wis	18

With the approval of the Chief of Engineers a contract was entered into July 29, 1891, with Christopher H. Starke, the lowest responsible bidder, for this work.

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COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

Name of harbor, Milwaukee, Wis.; collection district, Milwaukee, Wis.; nearest port of entry, Milwaukee, Wis.; amount of revenue collected during the year $365,922.16.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	3,873	3,158,757	3,771	3,147,735
Sail	2,069	372,420	2,011	361,980
Total	5,942	3,531,177	5,782	3,509,715

The following extracts taken from the annual report of the secretary of the chamber of commerce for the fiscal year ending April 4, 1892, show the receipts and shipments of some of the leading articles of commerce at the harbor and city of Milwaukee during the year:

Receipts and shipments.

Receipts:	Tons.
Barley by (rail and lake)	235,030½
Barley (local consumption)	105,893
Butter	1,997¼
Cedar posts	12,332
Cheese (Wisconsin)	6,452½
Coal (by lake)	1,006,656
Coal (by rail)	149,377
Corn	32,569
Eggs	2,716¾
Firewood	231,032
Flaxseed	17,382½
Flour	272,756¾
Hides	11,497¼
Hides (manufactured into leather)	6,184½
Hogs	69,576
Hops	1,057¼
Iron ore	134,324
Lumber	541,689
Lath	4,851¼
Malt	116,936
Mill stuffs	24,163
Oats	76,795
Pig iron	35,292
Potatoes	5,385¾
Salt	93,974
Shingles	16,184½
Tallow	499½
Wheat	325,394¾
Wool	1,962¾
Total	3,539,961¾

Shipments:	Tons.
Barley	129,899½
Butter	165¼
Coal	600,888
Corn	13,356¼
Flax-seed	16,164¾
Flour	409,812¾
Hides	674½
Hogs	4,894¼
Lard	3,376¾
Lumber	261,582¼
Lath	1,831½
Malt	51,816¾
Meat (bulk)	6,861¼
Mill stuffs	90,624
Oats	38,698
Pork, beef, hams, shoulders, and middles	25,016½
Pig iron	38,481
Potatoes	1,675½
Salt	84,346
Shingles	11,895
Wheat	82,932¼
Total	1,874,992¼

Bank deposits	$865,401,940.58
Receipts of office of internal revenue	3,276,630.42

The number of manufacturing establishments in the city of Milwaukee is 3,258. The number of persons employed in these establishments is 55,890. The capital invested in manufactures is $80,506,500. The value of products during the year, $129,347,885. Two new lines of steamers have been established, connecting with railroad lines on the east shore of Lake Michigan, one of which connects with St. Joseph, Mich., the other with the railroad lines at Benton Harbor. Milwaukee has now five independent lines of steamers plying across the lake, besides the lines of coastwise steamers along the west shore.

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I I 18.

IMPROVEMENT OF RACINE HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into Root River, at the mouth of which the city and harbor of Racine are situated.

Project.—The original project for the improvement of this harbor was made and adopted in 1842–1843. Its intention was to provide and maintain a channel 12 feet deep by dredging between protection piers constructed of cribwork placed parallel to each other and 160 feet apart, the distance from the shore line to 12 feet of water in Lake Michigan being about 800 feet.

In 1866 the project was modified with a view to providing a channel of 15 feet in depth.

Under this modification the north pier was extended 630 feet and the south pier about 500 feet. A further modification was made in 1889, which called for an extension of the north pier 300 feet, and of the south pier 500 feet, and an increase in the depth of water in the channel to 16 feet, at which time the north pier extended 380 feet farther into the lake than the south pier.

Present works.—The north pier is about 1,460 feet long. Its western section of 200 feet in length is 12 feet wide; its middle section, 960 feet in length, is 20 feet wide, and its outer or eastern section of 300 feet in length is 30 feet wide. The south pier is 1,270 feet long; its inner or western section of 530 feet in length is 16 feet wide, and its outer or eastern section is 740 feet long and 20 feet wide. The north or weather pier now extends 180 feet farther into Lake Michigan than the south pier.

Depth of water.—The natural depth of water on the bar in front of the mouth of the river before artificial improvement was made was variable. The effect of a northeast storm would be to deposit sand to such an extent as to completely obstruct the entrance until an accumulated head of water in the river became sufficient to remove the barrier, and upon a change of wind sometimes a narrow channel of 5 or 6 feet would be scoured out.

The work done under the project previous to 1860 provided a channel of from 9 to 10 feet in depth. The extension of the piers, with the periodical dredging which has been done since 1866, has generally maintained a channel of from 13 to 15 feet in depth, but the maintenance of a 15-foot channel is dependent upon a frequent use of the dredge.

A plat of soundings taken at this harbor in April, 1892, shows that under favorable conditions of weather a vessel drawing 13 feet of water can enter the harbor, but to again restore the channel to a depth of 15 feet and width of 80 feet would require the removal of about 13,000 cubic yards of material, scow measurement. To the northward of the harbor entrance the contour line of 12 feet overhangs the eastern extremity of the north pier, and the bar from the southward has again formed since excavation was made in June and July, 1891, by dredging to a depth of 15 feet.

Operations during the fiscal year.—Under the agreement made with Mr. S. O. Dixon, on the 15th day of June, 1891, the dredge had removed 4,089 cubic yards of material at the date of report of June 30, 1891. The restoration of the channel to the depth of 15 feet and width of 80 feet was completed during the month of July, the total quantity

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of material removed in its accomplishment was 14,273 cubic yards. Under the contract made with Messrs. Truman and Cooper, of date December 13, 1890, for extending the south pier into lake Michigan for a distance of 200 feet, by constructing 4 cribs, each of dimensions 50 by 20 by 18½ feet, and sinking them on a foundation of piles, the specified work was completed and a continuous superstructure built over them to a height of 6 feet above datum, before the 10th of October, 1891.

Remarks and recommendations.—Until both piers are extended farther into the lake, a frequent use of the dredge will be necessary. The superstructure of the western section of the north pier 200 feet in length by 12 feet in width, and 635 feet of its middle section of 20 feet in width is in a dilapidated condition, as is also 310 feet in length of the superstructure of the west end of the south pier. The damage to the crib at the outer end of the north pier, caused by the collision of the steamer *City of Ludington*, of the Goodrich Transportation Company, on the morning of the 20th of December, 1891, is of a serious character, by reason of the expense and difficulty incurred in repairing structures which are fractured below the water surface. The broken timbers of this crib will have to be removed and replaced by new material to a depth of 4 or more feet below datum.

Each of the piers should be extended 300 feet. In 1880 it was estimated that an average yearly expenditure of $8,000 would be required for the maintenance of this harbor. Since that time the total sum of appropriations made has been $63,500, of which $21,000 has been applied to pier extension, so that the average yearly expenditure for maintenance of channel and repairs to piers has been but $3,541.66 per year for the past twelve years. This amount is inadequate to the maintenance of the harbor as is apparent from its present condition.

APPROPRIATIONS.

Act of—		Act of—	
June 15, 1844	$12,500	June 18, 1878	$10,000
August 30, 1852	10,000	March 3, 1879	6,000
June 28, 1864	3,600	June 14, 1880	6,000
June 23, 1866	23,910	March 3, 1881	6,000
March 2, 1867	45,000	August 2, 1882	7,000
April 10, 1869 (allotted)	22,275	July 5, 1884	7,000
July 11, 1870	10,000	August 5, 1886	10,000
March 3, 1871	10,000	August 11, 1888	10,000
March 3, 1873	20,000	September 19, 1890	17,500
June 23, 1874	10,000	July 13, 1892	25,000
March 3, 1875	10,000		
August 14, 1876	8,000	Total	289,785

Money statement.

July 1, 1891, balance unexpended	$17,643.88
June 30, 1892, amount expended during fiscal year	16,642.71
July 1, 1892, balance unexpended	1,001.17
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	26,001.17
Amount (estimated) required for completion of existing project	39,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	39,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. L. H. Coleman, City Clerk.]

Name of harbor, Racine, Wisconsin; collection district, Milwaukee, Wis.; nearest port of entry, Milwaukee, Wis.; amount of revenue collected at the nearest port of entry, $365,922.16.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	699	465,085	697	464,708
Sail	525	70,563	531	70,883
Total	1,224	535,648	1,228	535,591

Principal articles of export and import.

Exports:	Tons.
Agricultural implements	39,111¼
Apples	15
Beer	4,348¾
Brick	26,870
Chairs	221½
Coal and coke	19,400
Fish	24
Flour	537½
Hay	14,120
Lath	550
Leather	555¼
Lime and cement	3,625
Merchandise (general)	153,725
Mill stuffs	12.818
Oats	328
Oil	1,968
Pork and beef	61
Posts (fence)	1,149½
Potatoes	360
Provisions	375
Sash, doors, and blinds	252
Shingles	180
Shoes	520
Stone	4,340
Wagons and carriages	10,535
Wood	2,125
Wool	105
Total	298,319¾

Total approximate value, $9,889,117.50.

Imports:	
Agricultural implements	617¾
Apples	202½
Bark (tan)	1,941½
Barley	2,595
Beer	6,142½
Brick	700
Butter	18¾

Imports—continued.	Tons.
Cheese	75¼
Coal and coke	100,490
Corn	693½
Eggs	39½
Fish	125
Flour	596¾
Furniture	5,699
Gambier	348¾
Hay	5,675
Hides	854¾
Iron and steel	27,633
Hogs	435½
Lath	756¼
Leather	300¾
Lime and cement	290
Lumber	67,500
Marble	50
Merchandise (general)	1,621,593
Mill stuffs	400
Oats	1,191¼
Oil	2,173¾
Poles (telegraph)	34
Posts (fence)	1,564¼
Potatoes	219½
Printing paper	311½
Provisions	389½
Salt	1,746¾
Sash, doors, and blinds	108½
Sheep	977½
Sheepskins	141½
Shingles	337½
Tobacco	48½
Wheat	6,191½
Wood	39,875
Wooden ware	274¾
Wool	96¼
Total	1,901,454¾

Total approximate value, $6,047,496.80.

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I I 19.

IMPROVEMENT OF KENOSHA HARBOR, WISCONSIN.

Object.—To secure a navigable channel from Lake Michigan into the extensive basin at the mouth of Pike Creek, upon which the city and harbor of Kenosha are situated.

Project.—The original project for the improvement of this harbor, adopted in 1852, was to secure a channel 12 feet deep from 12 feet of water in Lake Michigan to the interior basin or bayou by the construction of piers placed parallel to each other and 150 feet apart, and by dredging between them. In 1866 a modification of the original project was made in order to provide a navigable channel 15 feet in depth.

A further modification or extension of the project was made in 1889, which provided for the extension of the north pier 300 feet and of the south pier 600 feet.

Present works.—The north pier is 1,600 feet long. Its inner or western section, which was built either by private parties or the city of Kenosha, is of pile work, 365 feet in length, and is 12 feet wide. The adjoining section to the eastward, built under the original project of 1852, is of crib work 610 feet long and 18 feet wide. The extension of this pier since 1866 is 625 feet long, 250 feet of which is 30 feet wide. The south pier is 950 feet long and 20 feet wide, commencing at the shore line and extending into the lake. The north pier extends 270 feet farther into the lake than the south pier.

Depth of water.—The natural depth of water at the mouth of Pike Creek before it was improved changed with each recurring easterly storm; not more than 2 or 3 feet could be depended upon at the entrance. The work first done under the project furnished a channel of from 9 to 10 feet in depth between the piers.

The extensions of the piers since 1866, together with periodical dredging, have generally provided a channel about 12 feet in depth, but in order to maintain a greater depth of water frequent dredging has been necessary.

A plat of soundings which were taken at this harbor in April, 1892, shows an available depth of but 12½ feet of water in the channel. A small bank in mid-channel has but 12 feet of water over it. An extensive deposit of sand has been made since dredging was done in June, 1891. To restore the channel to a depth of 15 feet and width of 80 feet will require the removal of about 15,000 cubic yards of material, scow measurement.

The contour line of 13 feet extends 200 feet beyond the outer end of the north pier, and the bank to the southward of the harbor entrance is about 600 feet outside the eastern extremity of the south pier. Under such conditions it is improbable that a channel of greater depth than about 12½ feet of water can be maintained, except by a constant use of the dredge.

Operations during the fiscal year.—At the close of the fiscal year ending June 30, 1891, the three cribs which were built under the contract made with Messrs. Truman & Cooper, of date December 13, 1890, for extending the south pier 150 feet, were sunk in position. The superstructure was subsequently built and supplied with stone ballast and covered with a decking of 3-inch plank. The contract was closed July 20, 1891. An agreement was entered into with Mr. S. O. Dixon on May 5, 1892, for restoring the channel to 15 feet in depth and 80 feet in width for its whole length, at a cost of 18½ cents per cubic yard of ma-

terial removed by the dredge. Under this agreement 8,064 cubic yards have been removed up to date.

Remarks and recommendations.—Until both piers are extended farther into the lake, a frequent use of the dredge will be necessary.

The superstructure of about 800 feet of the north pier, which was built in 1874 and 1875, is in a very bad condition and should be renewed. Many of the cross ties have rotted, and are broken and have fallen out of the gains, leaving no support to the side walls.

In 1880 it was estimated that to maintain the harbor an annual expenditure of $8,000 would be necessary. Since that time the total amount of appropriations for this harbor has been $46,000, of which $16,498.41 has been applied to pier extension and dredging in the interior basin, so that the average yearly expenditure for maintenance of channel and repairs to piers has been only $2,458.46 per year for the past twelve years. It has been necessary to expend a large portion of this for dredging so as to give temporary relief.

APPROPRIATIONS.

Act of—		Act of—	
June 15, 1844	$12,500.00	March 3, 1879	$5,000.00
March 3, 1845	15,000.00	June 14, 1880	5,000.00
August 30, 1852	10,000.00	March 3, 1881	5,000.00
June 23, 1866	75,461.41	August 2, 1882	6,000.00
April 10, 1869 (allotted)	5,346.00	July 5, 1884	5,000.00
July 11, 1870	10,000.00	August 5, 1886	5,000.00
March 3, 1871	10,000.00	August 11, 1888	7,500.00
June 10, 1872	10,000.00	September 19, 1890	17,500.00
June 23, 1874	10,000.00	July 13, 1892	15,000.00
March 3, 1875	15,000.00		
August 14, 1876	8,000.00	Total	260,307.41
June 18, 1878	8,000.00		

Money statement.

July 1, 1891, balance unexpended	$16,049.03
June 30, 1892, amount expended during fiscal year	11,674.67
July 1, 1892, balance unexpended	4,374.36
July 1, 1892, outstanding liabilities	1,491.84
July 1, 1892, balance available	2,882.52
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	17,882.52
Amount (estimated) required for completion of existing project	49,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	49,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. O. M. Pettit, mayor.]

Name of harbor, Kenosha, Wis.; collection district, Milwaukee, Wis.; nearest port of entry, Milwaukee, Wis.; amount of revenue collected at the nearest port of entry, $365,922.16.

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Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	72	11,379	72	11,358
Sail	195	27,812	194	27,510
Total	267	39,191	266	38,868

Principal articles of export and import (harbor only).

Exports—	Tons.
Cattle	3
Feed	6
Hay	800
Horses	1.5
Oats	112
Salt	60
Sand	6,750
Total	7,729.8
Imports—	
Bark (tan)	16,500
Coal and coke	10,500

Imports—Continued.	Tons.
Hides	125
Lath	302.5
Lumber (hard and soft)	22,750
Peaches	6
Piles	120
Posts (fence)	228
Shingles	450
Slabs	300
Stone	5,600
Wood	2,750
Total	59,631½

I I 20.

IMPROVEMENT OF WAUKEGAN HARBOR, ILLINOIS.

Object.—To provide a shelter for the protection of vessels engaged in the commerce of the city of Waukegan.

Project.—In 1852 an appropriation of $15,000 was made for the "improvement of the harbor and breakwater at Waukegan, Ill." The plan adopted was a breakwater parallel to the shore in 20 feet of water. One crib, 30 by 25 feet, was placed in position, but was carried away by a storm and the work then abandoned. In 1872 an examination and report were made, as called for by the river and harbor act of that year. This plan contemplated a breakwater in 24 feet of water. No action was taken on this report.

The character of the improvement of this harbor is somewhat different from that of other points on the Great Lakes. Most of the improvements have consisted in deepening the mouths of streams emptying into the lake, but at Waukegan there is only a creek emptying into the lake, and it is of no importance for harbor purposes.

The present project was adopted in 1880, its intention being to construct an exterior basin of sufficient capacity to meet the requirements of the local trade by inclosing a portion of Lake Michigan within piers constructed of pile work, and an entrance channel between piers from a depth of 12 feet of water in Lake Michigan to the basin; the channel and basin to be excavated by dredging to the depth of 12 feet.

Present works.—The length of the north pier is 1,651.6 feet; the length of the south pier is 1,226.9 feet, making a total length of pier work of 2,878.5 feet. The north pier, which incloses the basin, is comprised of four sections, the first of which runs easterly from inside the shore line as it existed in 1879 for a distance of 345 feet into the lake.

This section is comprised of a single row of 12 by 12 inch squared pine piles, reënforced at the angle or outer end for a length of 80 feet with oak piles driven at a distance of 12 feet from the front row, the interior space being filled with stone ballast.

The next section of pile work, 16 feet wide, runs in a southerly direction for a distance of 380.8 feet to the channel angle.

The next section of 16 feet in width, which runs in a southeasterly direction for a distance of 533.8 feet from the channel angle, is comprised of two rows of closely driven white oak piles, divided into sections by cross rows driven at distances of about 32 feet apart, double sheeted with 3-inch pine plank, and filled with stone ballast to a height of 2 feet above datum.

The outer section, of 16 feet in width and 392 feet in length, is constructed in the same manner as the preceding section, and is parallel to the line of the south pier, the distance between the piers being 236 feet.

The south pier is built upon a prolongation of the line of the south side of Madison street in the city of Waukegan. The inshore section of this pier, 140.3 feet, is comprised of a single row of square pine piles of dimensions 12 by 12 inches by 18 feet, with the exception of the outer 24 piles, which are 22 feet in length and 12 inches square.

The next outer section of 100 feet in length is constructed of round white oak piles, each 30 feet in length, on alignment at distances of 3 feet from center to center, and sheeted with two rows of planks of dimensions 3 inches by 12 inches by 22 feet, driven close and breaking joints, and spiked to the wales which inclose and secure the round piles.

The next section to the eastward, of 109 feet in length, is built with round white oak piles, each 30 feet long, driven at distances of 3 feet from center to center and secured with binders. On the south side of this row pine piles of 8 inches by 12 inches by 26 feet are driven in close contact and bolted to the binder and reënforced with a pine binder of 3 by 12 inches. The outer section of this pier is 877.6 feet long, and is comprised of two parallel rows of white oak piles, driven in close contact at a distance of 14 feet from center to center of rows, and is divided into sections of about 32 feet each. For a length of 675 feet of this section the piles are 31 feet long, and for the remainder 32 feet long. The rows of piles are secured and bound in place by means of wales, binders, screw bolts, and tie rods, in a similar manner to those of the outer section of the north pier.

On the south side of the north row a double sheeting of pine plank 3 inches by 12 inches by 22 feet is driven and spiked to the wales in a similar manner to the second section. The interior of this section has been filled with stone ballast to a height of 2 feet above datum, but in some places it has settled somewhat below that level.

In the construction of these piers it has been necessary to place a riprap of stone along the outer sides of the piles as fast as they have been driven.

Depth of water.—Before work was commenced upon this harbor the distance from the line of shore, in front of which the piers have been constructed, to the natural depth of 12 feet of water in Lake Michigan, was about 870 feet, but as the work has progressed an extensive accretion has been formed to the northward of the harbor. The shore line now intersects the north pier at a distance of 700 feet outside, or to the eastward of the line of shore as it existed in 1879, and the contour line of 12 feet of water is about 450 feet outside that former

line of depth, or more than 1,300 feet to the eastward of the line of shore of 1879.

A plat of soundings taken at this harbor in April, 1892, shows that a narrow channel of 7 feet in depth near the north pier is available for vessels of light draft.

Operations during the fiscal year.—At the close of the fiscal year ending June 30, 1891, six sections of pile work, each 32 feet long, being 192 feet in length, had been completed in extension of the north pier, the work being done by hired labor and the purchase of materials in open market. Subsequently six more sections, forming an additional length of 200 running feet, were built, making a total length of extension to the north pier of 392 feet, under the provisions of the river and harbor act of September 19, 1890, which appropriated $35,000 for the improvement of Waukegan Harbor. This extension was completed on the 18th day of August, 1891, when the pile-driver was transferred from the north to the south pier for its further extension. Work was continued on the south pier until November 11, 1891, at which date 202 running feet of extension had been built, and the pile-driver laid up and secured for the winter.

Two board fences have been constructed for the purpose of arresting the sand drift of the beach to the northward of the harbor from being carried into the channel and basin. One of these is 176 feet long and the other 128 feet. While they have not completely checked the drift, a large quantity of sand has been retained upon the beach through their instrumentality which otherwise would have been carried into the harbor.

Bids were received and opened on March 16, 1892, in answer to advertisement of February 15, 1892, inviting proposals from contractors for dredging in the entrance channel and harbor basin to a uniform depth of 12 feet below datum. The bid of the Green Bay Dredge and Pile Driver Company was the lowest offer made, and a contract was made with that company on the 23d day of March, 1892, to dredge and remove 60,000 cubic yards of material at 13⅜ cents per cubic yard, the work to be completed on or before October 31, 1892.

Up to date 9,714.6 cubic yards of material have been removed under this contract.

Remarks and recommendations.—The satisfactory manner in which the extensions to the piers were made during the working season of 1891, together forming a total length of 594 running feet, with one pile-driver and crew of nine men, was partly due to the preparations which were made during the winter of 1890 and 1891 by the purchase and delivery of materials, but chiefly to the systematic work done by the overseer and his crew of men.

About 130 cords of stone are needed alongside the piers as riprap, to supply the deficiency caused through a settlement of that material by wave action.

The outlook for a large increase in the commerce and manufactures of Waukegan is very encouraging, and, in consequence, the value of real estate has been greatly enhanced. The facilities rendered by the present harbor are not considered by the citizens of the place as being adequate to the requirements of the growing demands; in view of which a petition was circulated among the business men for signature during the past winter, and addressed to the honorable the Secretary of War, asking that an ample appropriation be made for extending the harbor piers to the depth of 16 feet of water in Lake Michigan. A report upon this subject was called for, and made by me, dated February 15, 1892.

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APPROPRIATIONS.

Act of—	
August 30, 1852, for breakwater (outer)	$15,000
June 14, 1880	15,000
March 3, 1881	15,000
August 2, 1882	20,000
July 5, 1884	20,000
August 5, 1886	20,000
August 11, 1888	25,000
September 19, 1890	35,000
July 13, 1892	$25,000
Total appropriations for present harbor	175,000
Appropriation for outer breakwater	15,000
Total for former and present harbor	190,000

Money statement.

July 1, 1891, balance unexpended		$25,526.80
June 30, 1892, amount expended during fiscal year		13,027.07
July 1, 1892, balance unexpended		12,499.73
July 1, 1892, outstanding liabilities	$1,169.39	
July 1, 1892, amount covered by uncompleted contracts	7,830.61	
		9,000.00
July 1, 1892, balance available		3,499.73
Amount appropriated by act approved July 13, 1892		25,000.00
Amount available for fiscal year ending June 30, 1893		28,499.73
Amount (estimated) required for completion of existing project		61,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1886 and 1867.		

Improving harbor at Waukegan, Ill.—Abstract of proposals for dredging about 60,000 cubic yards of material, received in response to advertisement dated February 15, 1892, and opened March 16, 1892.

Amount of appropriation available for this work, $9,000.

No.	Name and address of bidder.	Price per cubic yard.
		Cents.
1	Chicago Dredging and Dock Co., Chicago, Ill	24
2	William A. Starke, Milwaukee, Wis	14½
3	White & Finch, Grand Haven, Mich	14½
4	Green Bay Dredge and Pile Driver Co., Green Bay, Wis	13¾
5	Samuel O. Dixon, Racine, Wis	14¼
6	James A. McMahon and Charles P. Montgomery	14⅞

With the approval of the Chief of Engineers a contract was entered into March 23, 1892, with the Green Bay Dredge and Pile Driver Company, the lowest responsible bidder, for this work.

COMMERCIAL STATISTICS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1891.

[Furnished by Mr. William Besley, mayor.]

Name of harbor, Waukegan, Ill.; collection district, Chicago, Ill.; nearest port of entry, Chicago, Ill., amount of revenue collected during the year, $5,983,589.87.

Arrivals and departures of vessels.

Description.	Arrivals.		Departures.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	203	20,811	203	20,811
Sail	165	31,740	165	31,740
Total	368	52,551	368	52,551

Principal articles of export and import.

Exports:	Tons.
Apples	75
Beer	1,575
Cattle	150
Evergreen trees	500
Hay	500
Leather	150
Sash, doors, and blinds	400
Sheep	1,200
Wire works	75,000
Wool	12½
Total	79,562½

Imports:	
Bark (tan)	440
Barley	176
Beer	1,750
Brick	18,000
Coal and coke	116,000
Corn	28,000
Flour	1,935

Imports—Continued.	Tons.
Furniture	562½
Hides	300
Hops	10
Lime and cement	972
Lath	825
Lumber	21,000
Malt	325
Merchandise (general)	25,000
Oil	675
Pork and beef	1,200
Posts (fence)	114
Potatoes	180
Salt	750
Shingles	900
Ties (railroad)	700
Wire-work products	75,000
Wood	10,000
Zinc ore	4,650
Total	309,464½

I I 21.

IMPROVEMENT OF FOX RIVER, WISCONSIN.

Object.—Originally to secure a cheap route of water transportation from the Mississippi River to the Great Lakes and Atlantic seaboard. The improvement of the Wisconsin River having been abandoned, the present object is to obtain a navigable channel, as far as existing works will permit, from Portage, on the Wisconsin River, to the harbor of Green Bay, a distance of 160 miles.

Project.—The original project called for slack-water navigation on the Fox River by means of locks and dams as part of the through transportation route. The present modified project is that recommended by the Board of Engineers of May 14, 1886, and is to deepen the Fox River by rock excavation and dredging from Montello to Green Bay to 6-feet depth and from Portage to Montello to 4 feet depth; to widen the river channels to 100 feet throughout; to deepen the channel between De Pere and Green Bay; to dredge the channel in the Neenah River; and to remove the bar at the mouth of the Fond du Lac River.

Present works.—The present works are as follows:

	Upper Fox.	Lower Fox.	Total.
Locks	9	18	27
Dams	7	10	17
Canals	4	8	12
Revetment walls		2	2
Total	20	38	58

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Of the locks, fourteen are of stone, built by the United States, and one stone lock built by the canal company and repaired in 1878. The remaining twelve are wooden locks, which have been rebuilt and repaired from time to time. No more masonry locks are to be built.

Of the dams, one is of masonry, ten of cribs, one of pile and cribs, one of pile and cribs with movable pass, and four of brush and stone.

Of the canals, only the one at Portage is revetted its entire length of about 2 miles, on both sides, with a timber revetment.

Of the two revetment walls, one is at Kaukauna and the other at Appleton. The former, about 1,200 feet long, is a dry-laid stone wall, built by the canal company, and may have to be rebuilt, as it shows signs of yielding; the latter is of cement-laid stone masonry, built by the United States in 1878.

Depth of water.—The fall from Menasha to Green Bay is about 170 feet, and on the Upper Fox, from Portage to Lake Winnebago, about 30 feet. Previous to any improvements the river was obstructed by rapids, and at places portages had to be made.

During the fiscal year ending June 30, 1892, navigation closed November 17, 1891. It was resumed on the Upper Fox April 16, and on the Lower Fox April 15, 1892. On the Upper Fox the water was so low during September, 1891, that the larger class boats were laid up for the remainder of the season. On the Lower Fox boats drawing 5 feet of water could run from Green Bay to Oshkosh until about August 1, 1891. By that time the mills at Neenah, Menasha, Appleton, and Kaukauna had drawn the water so low below the crests of the dams that there was not over 3 feet of water in the channel and at times but 6 inches on the breast wall of the Kaukauna first lock.

Operations during the fiscal year.—The guard gates at the head of Kaukauna Canal, under construction at the close of the last fiscal year, were completed. A channel 75 feet wide and 450 feet long was blasted and excavated through the rock bar at the river outlet of De Pere lock to a depth of from 4 to 12 inches below the level of the top of the lower miter sill of the lock. The channel at Grignon Rapids, above the upper dam at Appleton, was deepened to 7 feet below the level of the crest of the upper dam at Appleton, except for a distance of about 500 feet, where solid rock was found at a depth of less than 5 feet; this part of the channel requires blasting before excavation can be done. Dredging was also done in the Neenah Channel; at the mouth of the Fond du Lac River; at the entrance of Fox River into Lake Butte des Morts; in the Fox River between Green Bay and De Pere, completing a channel 12½ feet deep and 50 to 60 feet wide. Two dump scows were completed and various repairs made to plant.

Proceedings in condemnation have been instituted to acquire title to about 3½ acres of land near Appleton first lock, needed for the use of the lock and as a site for lock house and storehouse. Commissioners to appraise the land have been appointed by the court, and it is hoped the matter will be speedily settled.

The channel between Green Bay and De Pere was last year marked by twelve 16-foot spar buoys. These buoys were repainted this spring and one new one set to replace one carried away during the winter. They were then all turned over to the Light-House Establishment for future maintenance by authority of the Chief of Engineers and the Light-House Board.

For details of the work attention is invited to the report of Assistant Engineer Samuel Whitney, appended hereto:

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Remarks and recommendations.—The commercial use made of this waterway from Portage to Berlin Lock is inconsiderable; thence down to Oskosh it increases, and from the latter place all the way down to Green Bay it is quite extensive.

I am informed that it is expected to bring into the lower river this season not less than 160,000 cords of pulp wood for the use of the mills between Menasha and Neenah and De Pere.

The following remarks are from the report of Maj. Chas E. L. B. Davis, Corps of Engineers, 1891:

This river has its effect upon rates on all freight carried to points in the Fox River Valley, which is the most thickly settled portion of the interior of Wisconsin and an important manufacturing region. All freights during the season of navigation, and particularly heavy freights, are reduced to near the price of water carriage, whether carried by boat or by the competing railroads; and for the reason that it is a regulator of freight, it is of such value that the works should be maintained and the navigation improved at least to the extent contemplated by the modified project of 1884.

During the season of 1890 the water has been very low after August 14, below the crest of the Menasha Dam.

During the season of navigation the mill-owners have continued, and still continue, to take water from the pools above the Appleton and Menasha dams much in excess of the discharge of the Fox River, thus reducing the levels of Lake Winnebago and Little Lake Butte des Morts below the crests of the dams. This is a constantly growing evil. On the 8th of November, 1886, a suit was filed in equity in the United States court of the eastern district of Wisconsin against the Winnebago Paper Company and some thirty other mill-owners at Neenah and Menasha, to restrain them from taking water for hydraulic power, or other purposes, during the season of navigation, from the level of Lake Winnebago above the Government dam at the city of Menasha when the level of the water in said lake is at or below the crest of said dam. The defendants filed their plea, and on March 5, 1887, replication was duly filed. During the spring and summer of 1888 the United States produced witnesses, and took testimony from time to time before the master in chancery. The defendants obtained further time in which to put in their proof.

Mr. A. E. Thompson, special assistant United States attorney, whose letter is herewith appended, writes as follows about this suit:

There is also pending a suit in equity, commenced in the United States circuit court for the eastern district of Wisconsin, against the Winnebago Paper Company, and some thirty others, mill-owners at Neenah and Menasha. If possible the defendants will be required to close their proof during the present summer, so that the matter can be heard by the court either at the October or January term.

A supplemental bill of complaint has been filed in the circuit court of the United States for the eastern district of Wisconsin bringing the complaint of the United States against the water users up to date of March 5, 1892.

In this bill Mr. A. E. Thompson, solicitor for the United States, recites as follows:

And by way of supplement your orator further says that ever since the filing of said original bill of complaint, during a part of each season, and especially in the months of July, August, September, October, and November during the season of navigation, and each year continuously thereafter until the spring freshets had filled up said pool, the said waters in said pool above the said dam have been and the same now are below the crest of the said dam at the city of Menasha, so caused and occasioned by the defendants taking and drawing water from below the crest of said dam as aforesaid, and each year since the filing of said original bill of complaint, and especially during the months of July, August, September, October, and November in each year, the defendants, by taking and drawing water from below the crest of said dam, have drawn the water in the pool above said dam below the crest thereof, and thereby rendered navigation uncertain and difficult, and have drawn the water down so that boats, vessels, and water crafts have been each year hindered and incommoded from passing along and upon the said Fox River, and thereby the public each year has been partially deprived of navigation of said river at and above the north and the south outlets of said Lake Winnebago, and between the said dam and the said lake, and on the waters of the canal aforesaid, and also as well through-

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out the entire length and breadth of said pool, extending from the said city of Menasha to the Eureka Dam aforesaid, and during the months of July, August, September, October, and November in each year since the year 1886 the said Fox River, between the Eureka Dam and the said city of Menasha, has become nearly unnavigable, and during each year since 1886 the property, rights of property, locks, dams, canals, and other improvement works of this complainant upon and along the said Fox River have been greatly injured and damaged thereby, and your orator fears that greater injury and damage to the property of the complainant and a total destruction of navigation will follow unless the defendants herein and above named, jointly and severally, be restrained from the continuance of drawing and taking water from below the crest of the said dam, or the taking of water from the level of the said pool when such level is below the crest of the said dam.

Your orator by way of supplement further says, that since the establishment of such limit, to which water might or may be drawn from said pool as aforesaid, and since said defendants had notice that the level of the water in said pool was at and below the crest of said dams as hereinbefore stated, as well before the filing of the original bill of complaint herein, and since said time, each and every year the said defendants have taken, and still continue to take and draw water from below the level of said pool, and below the crest of said dam, and ever since the first of August, 1891, the water in said pool has been by said defendants drawn down, and kept below the crest of said dam, and is now 3 feet or more below the crest of said dam, and said defendants insist that they will and shall continue to take and draw water from said pool when the surface of the water in said pool is at or below the crest of said dam, and which your orator fears they will do, and continue to do in the future, in defiance of the right of the complainant, and of the right of the public freely and uninterruptedly to navigate said waterways, and which if the defendants persist in, and insist upon carrying into execution, and continue to take and draw water from said pool, when the surface of the water in said pool is below the crest of said dam, will produce and cause great and irreparable injury and damage to the property and rights of property of the complainant, its locks, dams, canals, and other improvements along, on, and upon said Fox River, and will produce a partial, if not a total, destruction of public navigation on said Fox River.

Mr. Thompson informs me that this matter can not come before the court for argument until some time in October of this year. It is therefore probable that navigation will this season be again suspended by reason of use for water powers of more than the natural discharge of the river.

For the status of the cases now in court and of those contemplated by or against the United States, attention is invited to the appended report, dated Oshkosh, June 22, 1892, of Mr. A. E. Thompson, special assistant United States attorney:

List of appropriations made by Congress for the improvement of the Fox and Wisconsin rivers, Wisconsin.

Act of—	
March 2, 1867, for snag boat on Wisconsin River	$40,000
July 10, 1870, for improving Wisconsin River	100,000
June 10, 1872, for purchase of works on Fox River from Green Bay and Mississippi Canal Company	145,000
March 3, for improving Fox and Wisconsin rivers	300,000
June 23, 1874	300,000
March 3, 1875	500,000
August 14, 1876	270,000
June 18, 1878	250,000
March 3, 1879	150,000
June 14, 1880	125,000
March 3, 1881	125,000
August 2, 1882	200,000
July 5, 1884	160,000
August 5, 1886, for improving Fox River	56,250
August 11, 1888, for improving Fox River	100,000
September 19, 1890, for improving Fox River	100,000
July 13, 1892, for improving Fox River	75,000
Total	2,996,250

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Money statement.

July 1, 1891, balance unexpended	$76,470.31
June 30, 1892, amount expended during fiscal year	41,575.61
July 1, 1892, balance unexpended	34,894.70
July 1, 1892, outstanding liabilities	1,156.41
July 1, 1892, balance available	33,738.29
Amount appropriated by act approved July 13, 1892	75,000.00
Amount available for fiscal year ending June 30, 1893	108,738.29
Amount (estimated) required for completion of existing project	271,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. SAMUEL WHITNEY, ASSISTANT ENGINEER.

UNITED STATES FOX RIVER IMPROVEMENT,
ENGINEER OFFICE,
Oshkosh, Wis., June 30, 1892.

MAJOR: I have the honor to submit the following report of operations on the Fox River, Wisconsin, from Portage to Green Bay, for the fiscal year ending June 30, 1892.

Work during the year consisted principally in excavating a channel through the rock ledge at the river outlet of Depere Lock, in completing the guard-gates at Kaukauna, in completing by dredging of a 6-foot channel in the Neenah River and a 7-foot channel from Scott Street Bridge at Fond du Lac to the 7-foot curve in Lake Winnebago, in dredging the channel at Grignon Rapids (lower Fox), in completing two center dump scows, and making repairs of Dredge No. 3.

On the upper Fox the water became so low during the month of September, 1891, that the larger class of boats were obliged to lay up for the remainder of the season. Navigation was closed by ice November 17, 1891, and resumed April 10, 1892.

On the lower Fox boats drawing 5 feet of water could run from Green Bay to Oshkosh until about August 1, 1891, when the mills at Neenah, Menasha, Appleton, and Kaukauna had drawn the water so low below the crests of the dams that there was not over 3 feet of water in the channel, and at times there was a depth of but 6 inches on the breast wall of the Kaukauna, first lock. Navigation was closed by ice November 17, 1891, and resumed April 15, 1892.

The following outline of work done at the different points between Portage and Green Bay, under separate headings, viz: "Improving Fox River." and "Improving Fox and Wisconsin rivers, Wisconsin," is respectfully submitted.

IMPROVING FOX RIVER, WISCONSIN.

Blasting and dredging channel through rock bar at river outlet of De Pere Lock.—The work of excavating a channel 75 feet wide and 450 feet long, through the ledge of rock at the river outlet of the lock, was begun in November, 1891.

The drilling plant was put in good repair, placed on a scow and housed in. Drilling of rock was commenced on December 2 and completed February 10. One thousand and seventy-five holes, 2 inches in diameter, were drilled to a depth of about 4 feet and blasted. The total depth of holes drilled was 4,227 feet.

Dredge No. 2 was fitted out, and on February 19, 1892, commenced the removal of rock. Three thousand one hundred and seventeen cubic yards in place were excavated and banked at the left side of the channel, and as that side of the channel was the only place where the rock could be dumped, a large portion of it had to be rehandled by the dredge. The rock is of a good quality of limestone suitable for riprapping canal banks, etc. One thousand one hundred and ten cubic yards of mud, clay, etc., were dredged from a point just below the lower end of channel, placed in dump scows, towed to deep water in the river by the tug *General G. K. Warren*, and dumped. The dredging of the channel was carried to a depth of 4 to 12 inches below the level of the top of the lower miter sill of the lock. The work was completed May 3, 1892.

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CONSTRUCTION OF LOCKS, ETC.

Guard gates at the head of Kaukauna Canal.—Work on the gates, under construction at the close of the last fiscal year, was continued. The water was pumped from the sluiceway pit; 946 cubic yards of hard pan and bowlders were excavated for the foundations of the walls, and the masonry of walls completed. The cofferdams were then removed and the material used in the construction of a cofferdam around the site of the navigable pass; pumping machinery set and the water pumped out; 395 cubic yards of hard pan and rock were excavated for the foundation of walls of the pass and the wall connecting the right abutment of gates with the left abutment of Kaukauna Dam; the masonry of the right abutment and connecting wall completed; miter sills and gates for the pass and needle beams for the sluiceway were framed and put in place; cofferdams removed; two cast-iron snubbing posts set in place at the upper end of center pier and right abutment, and 570 cubic yards of clay embanked against the rear of the abutments.

The shed used for storing cement, etc., during the progress of the work was moved to a point near the right abutment of the gates and fitted up for the purpose of storing the needles used in closing the sluiceway between the center pier and left abutment; and 400 needles, 3 by 3 inches by 14 feet, were framed and stored in the house; 982¼ cubic yards of cement masonry and 44 yards of dry masonry were laid in the piers, abutments, and cross walls. The cut stone used in the work was brought from Kaukauna quarry, and the rubblestone from Little Chute and the third level of Kaukauna Canal. The work was completed, except placing four gate capstans, November 30, 1891.

REPAIRS OF BOATS AND DREDGES.

Dredge No. 3.—The boat was hauled out at Oshkosh; all the bottom plank, transverse floor timbers, 120 linear feet of keelsons, swinging engine bed timbers, 1 main beam, 2 posts, 2 hog-chain posts, 11 knees, and the floor in the hold, were removed and replaced by new material. A new crane, dipper handle, turn-table, 6 spud guides, and 3 spuds were made and put in place. New deck planks were put in where needed; tin roof of cabin repaired, and the hull thoroughly recalked. The machinery was removed, taken to a machine shop, put in good repair, and replaced. Repairs were completed and the dredge put in commission May 25, 1892.

Dredge No. 2.—There was purchased one 1¼-yard rock dipper.

Center dump scows.—The construction of two center dump scows, having a capacity of 65 cubic yards each, was continued; 2,140 feet, B. M., of bottom, 1,230 feet of pocket, and 2,444 feet of deck plank were jointed, fitted and spiked in place; 4 strakes of fenders made and bolted to the sides of scows; the windlasses, ratchets and pawls, for operating the pocket doors, fitted in place; 7 hatch covers made, and the calking of the pockets and decks completed. One of the scows was launched on the 17th, the other on the 18th, and both completed on the 20th of July, 1891.

DREDGING LOWER FOX.

Deepening channel at Grignon Rapids above the upper dam at Appleton.—Dredge No. 2 continued work in the channel from beginning of the fiscal year until October 31, except from August 24 to September 4, inclusive, during which time she was employed at Kaukauna guard gates; and Dredge No. 3 worked from October 4 to 28, inclusive; Dredge No. 3 being in need of extensive repairs suspended work on the last-mentioned date, and on November 3 was towed to Oshkosh to be hauled out for repairs during the winter.

Dredge No. 2 extended the first cut, 30 feet in width, a distance of 3,200 feet to the point where the Milwaukee and North Railway crosses the river; then moved back to the upstream end of the channel, 4,600 feet above the left end of the upper dam, and made a second cut about 2,000 feet in length and 25 feet in width. Dredge No. 3 commenced a third cut, 25 feet in width at the upstream end of the channel, and worked downstream a distance of 668 feet; 20,494 cubic yards of hard pan and limestone rock were removed by Dredge No. 2, 9,590 cubic yards of which were banked at the left side of the channel, and 10,904 cubic yards placed in dump scows, towed by the tugboat *General G. K. Warren* to deep water in Little Lake Butte des Morts, and dumped; 3,628 cubic yards of hard pan and bowlders were excavated by Dredge No. 3, all placed in dump scows, towed by the tugboat *Dekorra* to Little Lake Butte des Morts, and dumped.

The dredging was carried to a depth of 7 feet below the level of the crest of the upper dam at Appleton, except for a distance of about 500 feet, where solid rock was found at a depth of less than 5 feet. This part of the channel will have to be drilled and blasted before the required depth can be obtained by dredging.

Dredging Neenah Channel.—Dredge No. 3 continued the work of dredging a channel

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60 feet wide and to a depth of 6 feet below the level of the crest of the dam at Neenah. The second cut, 30 feet in width, was extended to the lower end of the channel about 500 feet above the dam, and the coamings between the first and second cuts cleaned up; 11,010 cubic yards of hard pan and bowlders were removed, 9,520 yards of which were placed in dump scows, towed to deep water in Lake Winnebago by the tugboat *Dekorra*, and dumped, and the remainder banked at the left side of the channel.

About 400 feet above the lower end of the channel a basin, 200 feet in diameter, was excavated to provide a place for boats to wind during low stages of water in the river.

August 31, the funds provided for dredging the channel having been expended, work was suspended and the dredging plant towed to Menasha.

Dredging channel at the motuh of Fond du Lac River.—Dredge No. 7 continued the work of dredging a channel 75 feet wide from the Scott Street Bridge to the mouth of the Fond du Lac River, thence to the 7-foot curve in Lake Winnebago, 150 feet wide, and to a depth of 7 feet below the level of the crest of Menasha Dam. The length of the river portion of the channel dredged is 4,225 feet, and the distance from the mouth of the river to the point in the lake where dredging ceased is 1,900 feet; 15,177 cubic yards of soft material were removed from the channel in the river and 29,954 cubic yards of sand and clay from the channel outside of the shore line of the lake, making a total of 45,131 cubic yards. The material, with the exception of 9,758 cubic yards, dumped on the left bank of the river, was placed in dump scows, towed to deep water to the westward of the mouth of the river and dumped.

Dredging was suspended August 24, and the dredge sent to remove a bar at the entrance of the Fox River into Lake Butte des Morts, which work having been completed September 11, the dredge returned to Fond du Lac and resumed work September 12.

October 8, the dredge had one of her bottom planks broken by striking on a sunken pile, which caused her to leak so badly that she filled with water and sank to the bottom of the river within ten minutes after; the leak was stopped with blankets, etc., water pumped from the hold, repairs made, and work resumed by the dredge on the 12th of October.

November 16, the necessary dredging of the channel having been completed, the dredge and dump scows were towed to Oshkosh and laid up for the winter.

The tugboat *General G. K. Warren* was employed in towing dump scows from July 1 until August 26, when, her services being needed at Grignon Rapids, the tugboat *W. W. Neff* was hired to attend the dredge for the remainder of the season, at $20 per day for each working day.

FOX AND WISCONSIN RIVER IMPROVEMENT.

Dredging Fox River between De Pere and Green Bay.—In July, 1891, twelve buoys 16 feet in length, 10 inches in diameter midway between the ends, 8 inches at the lower and 7 inches at the upper end, were made and painted two coats of red. Cast-iron anchors, hemispherical in shape and weighing 337 pounds each, and the necessary three-eighths inch chains and swivels for securing buoys to anchors were provided.

During the month of August the channel was sounded from a point about 1,300 feet from the lower end of De Pere Lock to a point 3.71 miles down river and the soundings platted on a map drawn to a scale of $\frac{1}{2400}$. The buoys were set on the right side of the channel (going in) at distances of 1,220 to 2,425 feet apart, and numbered with even numbers, commencing with the one farthest downstream, thus: 2, 4, 6, 8, 10, etc. During the fall of 1891 Buoy No. 6 was carried away, and in the spring following a new one was made and put in place.

The soundings taken in the channel showed a depth of but 11½ feet of water below datum between buoys Nos. 6 and 10, and on May 4, 1892, Dredge No. 2 was sent to deepen that part of the channel, and by June 10 following removed 13,577 cubic yards of soft material, all of which was placed in dump scows, towed by the tugboat *General G. K. Warren* to a point near the right bank of the river and dumped. The balance available for the work having been expended, work was suspended and the plant towed to Kaukauna.

MISCELLANEOUS.

The tugboat *Boscobel* was employed on the Upper Fox River until May 24, 1892, in towing dredges from place to place and supplying them with fuel; in towing scow loads of material for repairs of locks, dams, and canal banks, and in making inspection trips. On May 25 the *Boscobel* was transferred to the Lower Fox, where she was employed for the remainder of the fiscal year in towing dump scows for Dredge No. 3, and in making inspection trips.

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The tugboat *Dekorra* was employed in towing dump scows for Dredge No. 3 at Neenah, Menasha, and Grignon Rapids until October 28, 1891, and from that date until November 3 in towing Dredge No. 3 and one dump scow to Oshkosh for repairs.

The *Dekorra* was laid up at Oshkosh, and during the winter was lengthened and repaired and renamed *Fox*. On the 25th of May she went to the Upper Fox, where she was employed until the close of the fiscal year in towing dredges from place to place, in towing scow loads of material for the repairs of Princeton Dam, and in making inspection trips.

The tugboat *General G. K. Warren* was employed in towing dump scows for Dredge No. 7 at Fond du Lac and for Dredge No. 2 at Grignon Rapids and in the channel between De Pere and Green Bay.

The steam launch *General Mead* was not put in commission, as her hull is badly decayed and needs rebuilding. During last season she was occasionally employed in towing scow loads of material for the guard gates at Kaukauna; a crew to run her being taken from the force at the guard gates whenever her services were needed. At the close of last season she was hauled out on the canal bank below the Kaukauan second lock and housed in.

CARE OF PROPERTY.

The old hull of Dredge No. 5, in use at Oshkosh as a storehouse during the winter of 1890-'91, was towed to Berlin in the fall of 1891 and the property stored on her transferred to the warehouse at the lock.

Pump Dredge No. 6.—This dredge has not been in commission for the past two years. The hull is old and badly decayed, and to save the expense of pumping the water out of her every day she was hauled out on the bank of the canal below Berlin Lock in August, 1891.

Very respectfully, your obedient servant,

SAMUEL WHITNEY,
Assistant Engineer.

Maj. JAMES F. GREGORY,
Corps of Engineers, U. S. A.

REPORT OF MR. A. E. THOMPSON, SPECIAL ASSISTANT UNITED STATES ATTORNEY.

OSHKOSH, WIS., *June 22, 1892.*

MAJOR: There are now pending in the circuit court of the United States for the eastern district of Wisconsin thirteen cases against the United States on appeal from the awards made by commissioners appointed pursuant to the acts of Congress to appraise damages for flowage to lands caused by the works of improvement. Of these cases five originated in Winnebago County, six in Fond du Lac County, and one in Waushara County, and damage is claimed on account of the Menasha Dam. The other case was originally pending in Outagamie County and the damage is claimed to have been caused by the dam at Little Chute Rapids. The aggregate amount claimed in these thirteen cases is $210,818, and the aggregate amount awarded is $124,904.02. These cases were transferred to the circuit court of the United States for the eastern district of Wisconsin, pursuant to the provisions of the act of September 30, 1890.

The expectation was that some of these cases would be tried at the October (1891) term. On account of the sickness of his honor Judge Jenkins they were continued until the January term, 1892. They were set for trial for a day certain in February, but afterwards, on the application of the defendants, were continued until the 4th of April, at which time the defendants applied for and obtained a further continuance, and they now stand for trial commencing on September 12 next, when it is to be hoped that we shall be able to dispose of at least five of the most important ones.

There is also pending a suit in equity, commenced in the United States circuit court for the eastern district of Wisconsin, against the Winnebago Paper Company and a large number of others as defendants, being users of water for hydraulic purposes at Neenah and Menasha. It was found advisable on the part of the complainants to file an amended and supplemental bill. To this all the defendants have answered, and issue has been joined as to the allegations of the complainants' bill. Such of the defendants, however, as are users of water for hydraulic purposes on the outlet at Menasha have filed a cross bill against the United States and such of the

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defendants as are users of water on the Neenah outlet, the object of which, among other things, is to compel the restoration, as nearly as practicable, of the Neenah Channel to its former width and depth, the complainants averring that the United States has enlarged the Neenah Channel by the cutting away of the so-called "Council Tree Point" and by dredging, thereby to a great extent depriving them, the complainants in the cross bill, of their lawful right to the use of the waters not needed for the purposes of navigation which naturally would flow through the Menasha Channel.

The Green Bay and Mississippi Canal Company has also filed a cross bill against the United States, among other things alleging that said company stands in relation to the United States as a purchaser of the water powers created by the dams of the improvement, by the use of the surplus water not required for the purposes of navigetion, "with the rights of protection and preservation appurtenant thereto." The theory of this bill seems to be that the United States ought to be adjudged to make such improvements and alterations from time to time as may appear necessary to protect, promote, and enlarge such company's water powers, and that, if necessary, the United States should be compelled to establish on the Wolf River and at Portage City feeders sufficient to cause a constant and even flow of water in the lower Fox to the end that the hydraulic power of the stream shall be maintained in its greatest effectiveness. The United States has until the first Monday in August to except, demur, or answer to these cross bills. The questions raised, to say the least, are novel.

Prior to February 1, 1888, one E. G. Berry filed his petition in the office of the clerk of the circuit court of Fond du Lac County in the usual form, and commissioners were appointed. By some oversight the papers were lost sight of and no award was made. On petition to the court the matter was revived, new commissioners were appointed, a trial had, and an award of $180 made and filed. The time to appeal has not yet expired. The Government does not wish to appeal, and it is not probable that the claimant will.

In the cases of Christina Grallup and John Hanson, pending in Fond du Lac County, in which the entire records were lost, by order of the circuit court of Fond du Lac County the records have been restored by filing copies, and these cases are now pending in said court on appeal. But as I have received authority from the Attorney-General to compromise them, they probably will never be again tried.

I estimate that $7,000 will be used in the necessary preparation and trial of the actions now pending in the United States court.

The Manufacturing Investment Company, lessees of water power from the Green Bay and Mississippi Canal Company, and whose mills are situated near the fourth lock, Appleton, have commenced an excavation on grounds claimed by the United States adjacent to such lock. It is the intention of the Government to resist such encroachments, and the questions involved will have to be settled by the courts.

Very respectfully, yours,

A. E. THOMPSON,
Special Assistant U. S. Attorney.

COMMERCIAL STATISTICS.

List of articles transported on Fox River, Wisconsin, during the year 1891.

Articles.	Quantity.	Articles.	Quantity.	Articles.	Quantity.
	Tons.		*Tons.*		*Tons.*
Logs	110,070	Gravel	1,769	Potatoes	28
Cord wood	21,912	Sand	13,749	Apples	2
Pulp wood	32,214	Lime	3,488	Beer	30
Shingles	1,580	Clay	7,050	Fish	105
Lath	132	Brick	19,987	Horses	12
Lumber	11,243	Tile	57	Cattle	6
Stave bolts	220	Salt	1,092	Sheep	4
Shingle bolts	67	Sewer pipe	10	General merchandise	3,567
Railroad ties	315	Flour	1,052		
Coal	9,376	Mill stuffs	1,226	Total	262,888
Pig iron	2,007	Malt	270		
Stone	19,383	Ice	55		

Passengers, 37,226.

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List of boats navigating Fox River, between Portage and Green Bay, Wis., June, 1892.

Name of boat.	Draft.	Tonnage.	Steam or sail.	Name of boat.	Draft.	Tonnage.	Steam or sail.
	Feet.				*Feet.*		
Portage*	2	75	Steam.	D. W. Libbey (tug)†	3½	60	Steam.
S. D. Arnold*	4½	93	Do.	Oshkosh (tug)†	3	46	Do.
City of Berlin	3	150	Do.	Thos. Spear (tug)‡	10	41	Do.
B. F. Carter†	5	125	Do.	Time (tug)	(§)	(§)	Do.
Ossian Cook†	5	175	Do.	M. Brunette (barge)	(§)	(§)	Do.
John Dennessen	4½	15.40	Do.	Emma (scow)	4½	45	Sail.
Evalyn†	5½	150.66	Do.	Eclipse	3½	60	Do.
Fashion‡	3½	70	Do.	Georgie (scow)	5½	82	Do.
City of Fremont*	3½	100	Do.	Topsy (scow)	4½	72	Do.
K. M. Hutchinson	4½	189.96	Do.	Juilia (scow)	5	44	Do.
George Lacy	(§)	25	Do.	Sassy Jack (scow)	4	26	Do.
Lilly	4	4	Do.	Rose Bud (scow)	5	75	Do.
Laura May†	3	5.91	Do.	Venture (scow)	5½	91	Do.
J. H. Marston†	4½	150	Do.	Red Fox (scow)	3	40	Do.
Mark*	2½	30	Do.	Newbauer (scow)	2½	20	Do.
Henrietta†	5	125	Do.	Barge (Morning Bell)	3½	70	Tow.
John Lynch*	3	50	Do.	Barge (Mark)*	2½	90	Do.
Schiller (tug)	5½	13.60	Do.	Barge (D. W. Cady)*	4	75	Do.
O. B. Reed†	3½	75	Do.	Barge (Indian Queen)	4	45	Do.
Morning Bell (tug)	5	9	Do.	Barge (Jumbo)‖	4½	97	Do.
Viola (tug)	3½	7	Do.	Barge No. 1‖	5½	145	Do.
Agnes C. (tug)	6	10	Do.	Barge No. 2‖	5½	145	Do.
D. W. Cady (tug)*	2	20	Do.	Barge No. 3‖	5½	145	Do.
W. W. Neff (tug)†	3½	46.44	Do.	Barge No. 4‖	5½	145	Do.
M. D. Moore (tug)†	3½	60	Do.				

* Boats that run above Oshkosh.
† Boats that run to Winneconne occasionally.
‡ Runs between De Pere and Green Bay.
§ Not given.
‖ H. Collette.

Number of lockages on Fox River, Wisconsin, for the calendar year 1891.

No.	Lock.	Lockages.	No.	Lock.	Lockages.
1	De Pere	634	16	Appleton, second	384
2	Little Kaukauna	462	17	Appleton, first	507
3	Rapid Croche	429	18	Menasha	447
4	Kaukauna, fifth	482	19	Eureka	425
5	Kaukauna, fourth	476	20	Berlin	431
6	Kaukauna, third	538	21	White River	136
7	Kaukauna, second	555	22	Princeton	95
8	Kaukauna, first	551	23	Grand River	134
9	Little Chute, fourth } Combined	342	24	Montello	55
10	Little Chute, third } Combined	342	25	Governor Bend	20
11	Little Chute, second	328	26	Fort Winnebago	42
12	Little Chute, first	328	27	Portage City	32
13	Cedars	334			
14	Appleton, fourth	337		Total	9,222
15	Appleton, third	376			

I I 22.

OPERATING AND CARE OF LOCKS AND DAMS ON FOX RIVER, WISCONSIN.

The expenditures for maintaining the existing depth of navigation throughout the Fox River and canals; for repairs to mechanical constructions that have been completed and in use, but afterward injured by flood or otherwise; for current repairs to old locks and dams and lock houses, and for lock tenders' services, have been paid from the indefinite appropriation for "operating and care of canals and other works of navigation" provided by section 4 of river and harbor act of July 5, 1884.

In accordance with this section an itemized statement of the expenditures is appended herewith.

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The work during the last fiscal year has consisted principally in dredging the channel of the upper Fox River and in making repairs of boats, dredges, lock houses, locks, dams, and canal banks.

For details of the work, attention is invited to the appended report of Assistant Engineer Samuel Whitney.

Money statement.

July 1, 1891, balance unexpended	$63,998.29
June 30, 1892, amount expended during fiscal year	55,989.98
July 1, 1892, balance unexpended	8,008.31
July 1, 1892, outstanding liabilities	6,176.96
July 1, 1892, balance available	1,831.35
Amount allotted for expenditure in fiscal year ending June 30, 1893	40,000.00
Amount available for fiscal year ending June 30, 1893	41,831.35

REPORT OF MR. SAMUEL WHITNEY, ASSISTANT ENGINEER.

UNITED STATES FOX RIVER IMPROVEMENT, ENGINEER OFFICE,
Oshkosh, Wis., June 30, 1892.

MAJOR: I have the honor to submit the following report of operations under the head of "Operating and care of canals and other works of navigation on the Fox River" for the fiscal year ending June 30, 1892.

Work during the year consisted principally in dredging the channel of the Upper Fox River; in making repairs of boats, dredges, lock houses, and in making incidental repairs of locks, dams, and canal banks.

De Pere Lock.—Four cords of loose rock were removed from the lock chamber by rakes and a hand dredge.

De Pere Canal Banks.—A revetment wall of cement masonry, 46 feet in length and 10 feet in height, was built to sustain a portion of the left bank of the canal immediately above the lock. The slope of the bank was raised to a level of the top of the wall with 340 cubic yards of clay, and the canal face of the bank for a distance of 175 feet above the head of lock riprapped with 10 cords of stone brought from the rock cut below the lock.

Lock house at De Pere.—The old wooden foundation walls, which were badly decayed, were replaced by masonry walls, the roof reshingled, a new floor laid in the cellar, new stairs built to cellar and loft, front room replastered and papered, a porch built at the front of house, two new doors were fitted and hung in place; a footwalk built from the front to rear of house, and the woodwork of house, both inside and out, painted two coats. A new vault was made for the outhouse, and the outhouse put in good repair.

Little Kaukauna Lock.—Four solid timber gates were made, the old gates taken out, valves and gate hangings taken off and fitted to the gates, and the gates hung in place.

Little Kaukauna Dam.—No repairs were needed during the year.

Rapid Croche Lock.—The upper right gate having been knocked off its step by a passing boat, the gate was taken out, the step replaced and the gate rehung. Slight repairs were made to hangings of the other gates.

Rapid Croche Dam.—Four hundred and eighty-five cubic yards of clay were wheeled from the bank of the river and placed to repair the embankment at the rear of the right abutment that had been cut away by water passing through the sluice way; and to prevent further damage the foot of the embankment was well riprapped with 9 cords of large stone boated from the quarry at Kaukauna.

Kaukauna Fifth Lock.—The upper left gate was removed, one of the valve rods repaired, and the gate replaced. New racks were put on the valve rods of the upper right gate.

Kaukauna Fourth Lock.—The valve chains of the platform valves were repaired.

Kaukauna Third Lock.—Slight repairs were made to the valve chains.

Kaukauna Second Lock.—Eight new iron rollers were put in place under the gate spars.

Kaukauna First Lock.—During the winter of 1891-'92, four new solid timber gates were made, and early in the spring the old gates were removed from the lock to the canal bank; the valves, gate hangings, etc., were taken off, fitted to the new gates

and the gates hung in place. Slight repairs were made to the hand rails on the gates and the gearing of the bulkhead valves.

Kaukauna Canal Banks.—A break 35 feet in width, near the waste weir in the right bank in the fifth level, was repaired by filling with 345 cubic yards of clay and gravel; sink holes in bottom of the level filled with 285 cubic yards of clay, and low places in the right bank of the second, fourth, and fifth levels were filled with 438 cubic yards of clay and gravel.

Lock house at Kaukauna First Lock.—The house was repaired, and an addition, 22 by 28 feet by 1½ stories, built to it.

Lock house at Kaukauna Second Lock.—The old house, which stood partly in the street, was moved to a convenient place near the head of the lock and put in good repair. An addition, 22 by 28 feet by 1½ stories, was built, and the ground between the house and lock graded.

Kaukauna Warehouse.—An addition, 20 by 40 feet, was built to the north end, and the office in the old part painted and papered.

Kaukauna Dam.—The apron planks were thoroughly respiked.

Little Chute Combined Locks.—The valve platform at the middle gates was replanked with 2-inch pine plank; the platform valves provided with new filling of oak plank, and the valve chains repaired. Slight repairs were made to the upper gates.

Little Chute Canal banks.—One hundred and sixty cubic yards of clay were boated from Kaukauna and placed to strengthen the right bank at a point near the waste weir in the second level.

Little Chute Second Lock.—New bed timbers were framed and placed under upper right capstan platform, and four new iron rollers fitted in place under the gate spars.

Little Chute First Lock.—No repairs were needed during the year.

Little Chute Dam.—The dam is of crib work filled with stone, is 11 to 12 feet in height, and has a width of cross section of but 14 feet. Since the dam was built (1876) it has been gradually going over until it leaned from 12 to 17 inches. To strengthen the dam the width of the cross section was increased to 24 feet by building an apron of crib work 10 feet in height along the face of the dam. The crib work of the apron was filled with stone and the top of dam and apron covered with 3-inch pine plank. New crib piers were built between the sluice ways at the left end of dam; new needle stringers framed and bolted to the piers; new foot walk built from the left abutment to the sluice ways, and 15 cubic yards of clay puddle placed at the rear of left abutment. Three hundred and twenty-two cords of stone were boated from Menasha, 33 cords from the old second lock at Little Chute, and 4 cords were gathered from the bed of the river near the dam, for use in the work.

Cedars Lock.—Slight repairs were made to the gearing of the bulkhead valves.

Cedars Dam.—Two hundred and ninety-five and eighty-five one-hundredths cords of stone were boated from Menasha for use in the construction of an apron in front of the dam.

Appleton Fourth Lock.—A diamond block was framed and placed at the lower right hollow quoin, and the right wall of lock chamber covered with one thickness of inch boards and one thickness of 2-inch plank.

Appleton Lower Dam.—No repairs required.

Appleton Third and Second Locks.—No repairs needed.

Appleton Canal Banks.—The left bank of the fourth level, from the head of the canal to the lock (752 feet); 530 linear feet of the left bank of the third level and 894 linear feet of the left bank of the second level were riprapped with 21.85 cords of stone boated from Menasha, and 131 cords taken from the walls of the old first lock at Appleton. The low places in the left banks of the second and third levels were filled with 176 cubic yards of clay and gravel taken from the rear of the walls of the old first lock.

Appleton First Lock (old).—The old gates at lower end of the lock were removed, taken apart, and piled on the right bank of the second level. The dry masonry walls of the lock were taken down to a level with top of the bank of the second level, and the stone taken from the walls used to riprap the banks of the second, third, and fourth levels of the canal at Appleton.

A foot walk 4 feet in width was constructed from the lower end of the left wing wall of the old lock to the lower end of the retaining wall of the first level of the canal, and a footbridge built across the lower end of old lock. A flight of stairs was built from the end of the foot walk to the top of the retaining wall; also from the end of the footbridge to the top of the left wall of the stone lock.

The house over the feeder at the head of the lock was painted two coats.

Appleton First Lock (stone).—The upper left capstan platform was replanked and new platform built at the lower left gate. The protection crib at the lower end of the left wall was rebuilt from the surface of the water up, and 60 cubic yards of clay placed between the left wall of the stone lock and the right wall of the old lock.

Appleton Upper Dam.—The trussed beams supporting the sluice gates at the right end of dam were painted two coats.

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Lock House at Appleton Third Lock.—The house was moved from the head of the lock to a more convenient place near the foot of the second lock; a cellar built under the house, the outside newly clapboarded; a porch built at the front side, and the outside of house painted two coats.

Menasha Lock.—The suspension rods of the lower left gate were repaired and timbers for four gate bars were purchased.

Menasha Canal Bank.—No repairs required.

Menasha Dam.—Slight repairs were made to the hoisting chains of the sluice gates.

Eureka Dam.—During July, 1891, a washout at the rear of the left abutment was filled with 150 cubic yards of clay boated from a dredged bank 2 miles above the dam, and 190 cubic yards of gravel boated from Berlin was placed along the river side of the abutment. A break underneath the dam, at a point near the right abutment, was repaired by sinking 90 brush mats, 10 inches by 4 feet by 10 feet with 10 cords of stone, and placing over the mats 1,327 cubic yards of clay and gravel. A number of planks were removed from the apron and the washout underneath apron filled with 29 cords of stone, 17 cords of which were boated from Menasha and 12 cords from Berlin. Seventeen broken apron planks were replaced by new plank.

In March, 1892, the drawbridge over the navigable pass was entirely rebuilt and painted two coats. All of the posts and valves in the sluice way under the bridge were removed, new posts and valves framed and put in place, and low places in the backing of the dam were filled with 160 cubic yards of gravel, completing the repairs. The dam was built of piles and timber on quicksand foundation, and needs frequent repairs to prevent its being entirely washed away.

Eureka Lock.—Four gates, built at Oshkosh in the spring of 1891, were taken to the lock in July following and hung in place of the old ones. Four new capstan platforms were built, new gate spars were made, and four new tripod capstans, for maneuvering the gates, set in place, completing the repairs.

Berlin Dam (brush).—During the months of August and September, 1891, low places in the dam were raised to the original height of dam by placing 373 brush mats and 23 cords of stone; and the shore protection at the ends of dam repaired with 48 brush mats and 15 cords of stone.

Berlin Lock.—No repairs needed.

Berlin Lock House.—The kitchen floor was painted one coat and the eaves spout repaired.

White River Lock.—The fence around lock site was put in good repair.

White River Lock House—No repairs needed.

White River Dam (brush).—Low places in the dam were repaired with 138 brush mats and 32 cords of stone.

Protection of River Banks.—A pier composed of piles, brush mats, and stone, was constructed to prevent the further washing away of the right bank of the river below White River Lock. From a point about 200 feet below the lock, the pier extends a distance of 384 feet. Two rows of piles were driven at a distance of 12 feet apart; the piles in the front row were driven at distances of 8 feet, and those in the back row 16 feet from centers. A wale, 10 inches in diameter, was placed along the outside of the back row of piles below the water surface; through the wale and front row of piles tie-rods of 1-inch round iron were placed and the pier then filled with brush mats, sufficient stone being placed on each layer of mats to sink them in place.

To prevent the further caving into the river of the higher portion of the sand bank between the head of White River Lock and right end of dam, piles were driven at distances of 5 feet from centers; between the row of piles and the face of the bank, a distance of about 5 feet, brush mats were placed and covered with stone. The face of the bank was then graded to a proper slope and riprapped with stone. The length of protection is 531 feet.

Princeton Dam (brush).—Repairs of the dam were commenced on May 11, 1892, but owing to the high stage of water in the swamps, making it difficult to obtain the necessary brush, etc., work was suspended on June 15. Up to the time work was suspended brush had been cut, 1,016 mats, 10 inches by 4 feet by 10 feet made, and 305 of the mats sunk in place.

Princeton Lock.—No repairs required.

Princeton Lock House.—No repairs needed.

Grand River Lock.—No repairs needed.

Grand River Lock House.—No repairs needed.

Grand River Dam.—No repairs made.

Montello Dam.—No repairs made.

Montello Lock.—A gate spar was made and placed.

Montello Levee.—Dredge No. 5 commenced the work of strengthening the levee on June 3, 1892; 3,456 cubic yards of material have been excavated from the bed of Lake Buffalo and placed at the sides and top of the embankment.

Governor's Bend Lock.—No repairs required.

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Governor's Bend Dam (brush).—No repairs made.

Fort Winnebago Lock.—No repairs made.

Portage Canal.—Five thousand seven hundred and fifty-six linear feet of decayed coping timbers were removed from the retaining walls of the canal and replaced by new 10 by 12 inch pine timber, 2,733 linear feet being for the right and 3,023 feet for the left wall. Slight repairs were made to the waste weir in the right bank of the canal above Fort Winnebago Lock.

Portage Lock.—The old lower wing walls were replaced by new walls of crib work closely fitted together and filled with sand. The new walls are 8 feet wide and 7 feet in height at the downstream end, 12 feet wide and 12 feet in height where they join the lower hollow quoins of the lock, and 61½ feet in length.

All of the arms above the paddle arms in each of the four gates were strengthened by bolting 10 by 10 inch pine timber to the lower sides of the arms, the gate hangings were put in good-repair, three new gate spars made and put in place, and new planks put in the bulkhead at the upper end of the left wall of the lock chamber.

Warehouse at Portage Lock.—The roof was reshingled, the old studding and siding replaced by new material, a new double floor laid, a new window put in place, and the door repaired.

Portage Levee.—During the high-water stage of the Wisconsin River, in May, 1892, weak places in the levee, about ¼ mile below Portage Lock, were strengthened by placing 75 cubic yards of sand and by facing the river front of the levee for a short distance with plank.

REPAIRS OF BOATS AND DREDGES.

Steam tug Pokorra.—The boat was hauled out at Oshkosh in November, 1891, and during the following winter was cut in two about midships and lengthened 20 feet, making her 100 feet over all. Two longitudinal bulkheads were built in the hold; the old Howe trusses put in good repair; all of the deck, deck beams, and the stem removed and replaced by new material. New grouser and grouser box were made and the paddle wheels rebuilt.

A new marine boiler, 12 feet in length and 5 feet in diameter; two horizontal engines 12 inches bore and 36 inches stroke; new paddle wheel and crank shafts; the necessary steam pipes and fittings, smoke pipe, heater, and deck pump were purchased and set up on board. The old force pump formerly in use on the steamer *Neenah* was put in good repair and set in place. The cabin was entirely rebuilt. The repairs were completed and the boat put in commission May 25, 1892. The name of the boat was changed to *Fox*.

Steamtug Boscobel.—The engine slides were trued up, crossheads and boxes recessed and babbitted, two Jenkins globe valves were fitted in place, and 120 maple cogs purchased for the core wheel. Slight repairs were made to the wheel houses and paddle wheels. The machinery was cleaned, put together, and the boat put in commission April 16, 1892.

Dredge No. 2.—A new dipper-handle shaft with two steel pinions, chain wheel, and two cast-iron boxes for shaft were put in place on the crane; one new chain wheel put on the hand-wheel shaft; new endless chain, backing chain, and 125 feet hoisting chain were put in place, and new dipper-bail sheave and frame put on dipper. The old spuds and dipper handle were repaired, and three new spuds and a dipper handle were made ready for the iron work. Slight repairs were made to the hoisting drum and the machinery cleaned and put together, completing the repairs. The dredge was put in commission February 19, 1892.

Dredge No. 4.—Work on the dredge, undergoing repairs at the close of the last fiscal year, was continued. Two crane bumpers were made and bolted in place, six bunks were fitted up in the sleeping apartments for the crew, stairs were built from the deck to the boiler room, the inside of the cabin and tin roofing were painted, and wire screens fitted to four doors and twelve windows. The boiler and steam pipes were covered with Morehouse patent covering, and the setting up of machinery completed. The dredge was operated for two days in front of the boat yard and the machinery properly adjusted for work. Repairs were completed, the outfit put on board, and the dredge put in commission July 20, 1891. In May, 1892, the top, sides, and deck were recalked and the gallows frame painted.

Dredge No. 5.—New friction woods were put in the hoisting drums, the shafts and crossheads of the hoisting engines were trued up and boxes of same rebabbitted, a new cylinder cock and pipe provided for the exhaust of spud engine, and six new brass boxes put in the frames of the hoisting-chain sheaves. The lugs of the clam-shell bucket were reriveted in place, and steel bushing provided for all pin holes in clam shells. A new top shaft and sliding boxes were put in the clam-shell frame, pole steps of frame rebolted, and all pin holes in frame rebored and provided with new steel bushings. The machinery was cleaned and put together, completing the repairs. The dredge was put in commission April 27, 1892.

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Dredge No. 7.—A broken plank in the bottom of the hull was replaced by a new one, the starboard spud guides rebolted to hull, the old dipper handle repaired, and new one made ready for the iron work. A new door was put on the dipper and the dipper teeth repaired and reriveted in place.

The machinery was cleaned and put together, the outside of cabin and the tin roofing painted one coat, completing the repairs. The dredge was put in commission April 25, 1892.

Side Dump Scow No. 1.—The scow was hauled out in May, 1892; eleven graving pieces put in the bottom, side fenders and pocket door hinges repaired; two new pocket planks fitted and spiked in place, and the seams at the lower end of the pocket planks, and both rakes were recalked, completing repairs.

Center Dump Scows.—The rakes and the top sides of the two center dump scows were recalked during the month of May, 1892.

Flat Scows.—The construction of five scows, 16 by 15 by 3 feet, to be used as tenders to the five dredges, was commenced in May, 1892, and at the date of this report three of them were about half built and the framework of the other two commenced.

DREDGING UPPER FOX RIVER.

By Dredge No. 4.—The work of rebuilding the dredge having been completed on the 20th of July, 1891, she was put in commission on the same date and employed until the close of the season in dredging bars between Omro and the Berlin Bridge, as follows, viz: From a bar opposite the mouth of Waukau Creek 8,137 cubic yards of material were removed; bar 5 miles below Eureka Lock, 11,015 yards; bar at Fitz Patricks Bend, 4,258 yards; two bars near the village of Eureka, 8,883 yards; bar at the lower end of cut-off below Eureka Lock, 4,683 yards; bar at Sacramento, 4,886 yards, and bar one-half mile below Berlin Bridge, 4,419 yards. The dredge suspended work November 16, and was towed to Eureka Lock and laid up for the winter.

Work was resumed April 21, 1892, at the point where it was suspended in November; 5,808 cubic yards of sand and gravel were removed, completing the work of dredging a channel through the bar. On May 30 the dredge was towed to a point 3 miles above Berlin Lock by the steamer *Fox*, where the removal of a bar was commenced, and by the end of the fiscal year 5,282 cubic yards of sand had been removed.

Total number of cubic yards of material removed by the dredge during the fiscal year, 57,369.

By Dredge No. 5.—Dredge No. 5 continued the work of dredging bars between Montello and a point one mile below White River Lock, and removed material as follows, viz, from bars between Grand River Lock and the head of Lake Apuckawa, 23,448 cubic yards; from bars between the point where Mechan Creek enters the Fox River and the head of Princeton Lock, 10,191 yards; bar at the lower end of Princeton Lock, 1,301 yards; bar one and a half miles below Princeton Lock, 7,522 yards; bar one and a half miles below Princeton Bridge, 5,740 yards; bar 3 miles above White River Lock, 5,901 yards; bar below White River Lock, 12,145 yards. Work was suspended at White River Lock on Nov. 27 and the dredge laid up for the winter.

The dredge was put in good repair during the winter, and dredging resumed April 27, 1892; 4,669 cubic yards of sand were removed, completing the dredging of a channel through the bar below White River Lock. On the 8th of May the dredge was towed by the *Boscobel* to a point about 4 miles above Princeton Lock, where about 850 cubic yards of scattering bowlders were removed from the channel of the river. The work was completed on the 17th of the month, and on the following day the dredge was towed by the *Boscobel* to Montello; 9,794 cubic yards of sand were removed from the bar just below the lock by the 2d of June, and the dredge then moved above the lock and commenced the work of strengthening the levee at the foot of Buffalo Lake; 3,456 cubic yards of sand and mud were taken from the bed of the lake and placed on the levee.

Total number of yards removed from bars during the year, 81,561.

Total number of yards placed on the levee, 3,456.

By Dredge No. 7.—August 25, 1891, Dredge No. 7 was transferred from Fond du Lac to a bar at the entrance of Fox River into Lake Buttes des Morts. A cut 1,942 feet in length and 30 feet in width was made through the bar, from which 9,231 cubic yards of sand were removed. The work was completed on the 10th of September, and on the following day the dredge was towed back to Fond du Lac.

During the month of April, 1892, the dredge was put in good repair, and on the 25th of the month was towed from Oshkosh to Preachers Bend to widen the channel through the bar at that place; 8,456 cubic yards of clay were removed from the channel, which work having been completed on May 14 the dredge moved up to a bar below Omro and took out 4,029 cubic yards of sand. The dredge was then towed

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by the steamer *Fox* to Keyhole Bar, just above Omro, where she is still at work. From Keyhole Bar 9,438 cubic yards of sand and soft clay were removed.

Total number of yards of material removed by the dredge during the fiscal year, 31,154.

The total number of cubic yards of material removed from bars on the Upper Fox River was 170,084.

DREDGING LOWER FOX RIVER.

Menasha River and Canal.—Dredge No. 3 was employed from the 1st of September until October 3d following in removing scattering bowlders and other obstructions to navigation in the channel of Menasha River and Canal, between Menasha Lock and the upper highway bridge; 1,950 cubic yards of bowlders, large pieces of flat stone, etc., were taken out and placed in dump scows towed by the steamer *Dekorra* to deep water in Lake Winnebago, and dumped.

Kaukauna Canal.—Dredge No. 2 worked four days in August and five days in September, 1891, removing bowlders, etc., from the entrance to Kaukauna Canal; 1,889 cubic yards were removed, placed in dump scows, towed by the tugboat *General G. K. Warren* to deep water above the dam and dumped.

Dredge No. 3 was put in commission May 25, 1892, and was employed the remainder of the fiscal year in cleaning the canal at Kaukauna; 1,066 cubic yards of bowlders and clay were removed from the first level and 149 cubic yards of mud from the second level. The material dredged from the first level was placed in dump scows, towed by the steamer *Boscobel* to the dam and dumped; that taken from the second level was placed on the left bank of the canal.

SURVEYS.

The following surveys and maps were made, viz: Survey and map of land needed for site of lock house and warehouse at the right side of Appleton First Lock; survey and map of land needed for a roadway from the Kingston Road in Marquette County, Wis., through the lands of James Hardy and John Barrett to the site of the Grand River Lock, and a survey and map of a strip of land 70 feet in width at both sides of Montello Lock.

In February, 1892, the distance from the confluence of the Fox and Wolf rivers to Portage Lock, omitting Apuckawa and Buffalo lakes, was measured on the ice, stakes set at the river's edge at distances of 1 mile apart, and in June following eighty-one white oak section posts 24 feet in length were driven at the points marked by the stakes, and the proper section numbers placed on the posts. A tracing of the map of the upper Fox River was made and the section numbers located on the tracing.

Very respectfully, your obedient servant,

SAMUEL WHITNEY,
Assistant Engineer.

Maj. JAMES F. GREGORY,
Corps of Engineers, U. S. A.

OPERATING AND CARE OF CANALS AND OTHER WORKS OF NAVIGATION APPLIED TO FOX RIVER, WISCONSIN; SECTION 4 OF RIVER AND HARBOR ACT OF JULY 5, 1884.

Detailed statement of expenditures for fiscal year ending June 30, 1892, with itemized statement of expenses attached, as required by the above act of July 5, 1884.

Character of work, etc.	Item of expense.	Amount.	Total.
Repairs of De Pere Lock	Labor	$126.68	$126.68
Repairs of lock house at De Pere Lock	Materials	11.50	
Do	Labor	129.68	141.18
Repairs of canal bank at De Pere	Material	30.75	
Do	Labor	403.14	433.89
Repairs of Little Kaukauna Lock	Materials	764.36	
Do	Labor	493.34	1,257.70
Repairs of lock house, Little Kaukauna Lock	do	133.43	133.43
Repairs of Kaukauna Dam	Materials	16.97	16.97

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Detailed statement of expenditures for fiscal year ending June 30, 1892, etc.—Continued.

Character of work, etc.	Item of expense.	Amount.	Total.
Repairs of Kaukauna Canal	Labor	$39.50	$39.50
Repairs of warehouse, Kaukauna Lock	Materials	336.40	
Do	Labor	193.96	530.36
Repairs of Rapid Croche Lock	do	27.00	27.00
Repairs of Rapid Croche Dam	Labor and transportation.	154.75	154.75
Repairs of Kaukauna Fifth Lock	Materials	7.10	
Do	Labor	20.06	27.16
Repairs of Kaukauna Fifth Level	do	279.86	279.86
Repairs of Kaukauna Fourth Lock	do	15.50	15.50
Repairs of Kaukauna Fourth Level	do	87.17	87.17
Repairs of Kaukauna Third Lock	do	4.00	4.00
Repairs of Kaukauna Second Lock	Materials	24.00	
Do	Labor	4.50	28.50
Repairs of lock house, Kaukauna Second Lock	Materials	511.05	
Do	Labor	531.21	1,042.26
Repairs of Kaukauna First Lock	Materials	953.69	
Do	Labor	512.04	1,465.73
Repairs of Kaukauna Canal Banks	Materials	63.46	
Do	Labor	141.75	205.21
Repairs of lock house, Kaukauna First Lock	Materials	469.67	
Do	Labor	310.26	779.93
Repairs of Little Chute Combined Locks	Materials	55.03	
Do	Labor	111.43	166.46
Repairs of Little Chute Combined Locks Level	do	165.44	165.44
Repairs of Little Chute Second Lock	Materials	14.00	
Do	Labor	4.00	18.00
Repairs of Little Chute Dam	Materials	3,786.25	
Do	Labor	1,561.94	5,348.19
Repairs of Cedars Lock	Materials	3.60	3.60
Repairs of Cedars Dam	Labor and transportation.	1,035.47	1,035.47
Repairs of Appleton Fourth Lock	Materials	173.10	
Do	Labor	150.87	323.97
Repairs of Appleton Fourth Level	do	111.37	111.37
Repairs of Appleton Canal Banks	Labor and transportation.	272.34	272.34
Repairs of lock house, Appleton Third Lock	Materials	134.61	
Do	Labor	285.30	419.91
Repairs of Appleton Second Level	do	23.00	23.00
Repairs of Appleton First Lock	Materials	2.20	
Do	Labor	333.00	335.20
Repairs of Menasha Dam	Materials	4.38	4.38
Repairs of Menasha Lock	do.	1.25	1.25
Repairs of Eureka Lock	do	97.77	
Do	Labor	159.39	257.16
Repairs of Eureka Dam	Materials	578.19	
Do	Labor	1,214.20	1,792.39
Repairs of Berlin Dam	Materials	123.82	
Do	Labor	682.76	806.58

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Detailed statement of expenditures for fiscal year ending June 30, 1892, etc.—Continued.

Character of work, etc.	Item of expense.	Amount.	Total.
Repairs of lock house, Berlin Lock	Materials	$3.25	$3.25
Repairs of White River Lock	do	5.18	5.18
Repairs of dam at White River Lock	Labor and transportation.	356.59	356.59
Protection of river bank at White River Lock	Materials	932.13	
Do	Labor	743.46	1,675.59
Repairs of Princeton Dam	Materials	91.20	
Do	Labor	681.09	772.29
Repairs of Princeton Lock	Materials	16.52	16.52
Repairs of Portage Lock	do	476.10	
Do	Labor	683.30	1,159.40
Repairs of Portage Canal	Materials	1,524.72	
Do	Labor	1,094.67	2,619.39
Repairs of Portage Levee	do	88.99	88.99
Repairs of warehouse, Portage Lock	Materials	138.24	
Do	Labor	85.93	224.17
General repairs of locks	Materials	18.48	18.48
Dredging bars, Lower Fox	Fuel, supplies, etc	404.70	
Do	Labor	1,090.09	1,494.79
Dredging bars, Upper Fox	Fuel, supplies, etc	2,320.27	
Do	Labor	6,393.00	8,713.27
Repairs of boats and dredges	Rent of boat yard at Oshkosh.	100.00	
Do	Repairs of Dredge No. 2	540.01	
Do	Repairs of Dredge No. 3	23.41	
Do	Repairs of Dredge No. 4	1,358.53	
Do	Repairs of Dredge No. 5	403.84	
Do	Repairs of Dredge No. 7	434.83	
Do	Repairs of steamer Boscobel.	117.20	
Do	Repairs of steamer Gen. Warren.	7.00	
Do	Repairs of steamer Dekorra.	6,802.76	
Do	Repairs of dump scows	364.78	10,152.36
Maintenance of navigation	Lock-tenders' services	5,804.66	
Do	Gauge-keepers' services.	119.99	
Do	Labor and transportation.	7.62	
Do	Rope for lock lines	8.00	5,940.27
Care of works and property	Watchmen, labor, and transportation.	1,370.45	
Do	Traveling expenses of assistant engineers, overseers, etc.	53.74	
Do	Rent of storehouse, Appleton.	180.00	
Do	Rent of quarry at Kaukauna.	75.00	
Do	Notices of laws	7.00	1,686.19
Contingencies	Salaries of assistant engineers, clerks, etc.	2,645.00	
Do	Rent of office at Oshkosh.	198.00	
Do	Mileage of officers	178.56	
Do	Stationery	160.20	3,181.76
Total			55,989.98

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Itemized statement of expenses made from appropriation for operating and care of canals and other works of navigation, indefinite, act of July 5, 1884, applied to Fox River, Wisconsin.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1891.				
July 27	1	Jones & Laughlins, Limited	Chain	$355.24
27	2	A. L. Smith	Hire of house	45.00
27	3	Green Bay and Mississippi Canal Co.	Rent of quarry	75.00
27	4	Hired men	Services	93.56
30	5	John Jansen	Lumber	11.11
30	6	Butler Bros	Shovels, etc	14.75
30	7	L. Lindauer	Coal	35.61
30	8	M. V. Morehouse	Boiler covering, etc	86.94
30	9	Battis Bros	Labor	1.20
30	10	George F. Stroud estate	Cotton waste, etc	14.21
30	11	Doman & Manuel	Iron castings	16.32
30	12	Gillingham & Son	Iron, etc	19.99
30	13	D. P. Sanford	Oil, etc	21.56
30	14	F. H. Josslyn	Sheets, etc	20.48
30	15	McKenzie & Crawford	Wood, etc	67.65
30	16	J. A. Barnes	Iron castings, etc	95.38
30	17	K. M. Hutchinson	Rope, etc	114.13
30	18	W. H. Crawford	Iron pipe, etc	183.18
30	19	Conlee Lumber Co	Lumber	864.30
30	20	C. A. Peck	Oil, etc	15.73
30	21	H. Stedman	Lumber	25.81
30	22	Niels Johnson	Boiler rivets, etc	41.69
30	23	William Bannerman	Stone	60.00
31	24	The Morgan Co	Lumber, etc	36.60
31	25	A. Ross Houston	Services	200.00
31	26	James Clear	do	30.00
31	27	John M. Paige	do	30.00
31	28	Jerry Parkinson	do	25.00
31	29	John Lewis	do	25.00
31	30	George T. Allanson	do	30.00
31	31	Alexander Sims	do	25.00
31	32	John A. Banker	do	25.00
31	33	Gottlieb Jahnke	do	25.00
31	34	George Gifford	do	25.00
31	35	Gabriel Wick	do	25.00
31	36	John Baeten	do	25.00
31	37	Richard E. Rice	do	25.00
31	38	C. L. Neumann	do	10.00
31	39	Joys Bros. & Co	Rope	11.41
31	40	Des Forges & Co	Stationery	34.28
Aug. 3	41	Samuel Whitney	Services	200.00
4	42	Hired men	Services, July, 1891	2,311.97
8	43	Jones & Laughlins, Limited	Chain	41.20
19	44	Julius Lando	Tapelines	15.50
21	45	J. M. Harford	Services	14.43
26	46	Louis Clairmont	Moving stone	225.00
31	47	Paul E. Thomas	Services	65.00
31	48	Samuel Whitney	do	200.00
31	49	John M. Paige	do	30.00
31	50	Alexander Sims	do	25.00
31	51	George T. Allanson	do	30.00
31	52	George Gifford	do	25.00
31	53	Jerry Parkinson	do	25.00
31	54	John Lewis	do	25.00
31	55	James Clear	do	30.00
31	56	John A. Banker	do	25.00
31	57	John Baeten	do	25.00
31	58	Gabriel Wick	do	25.00
31	59	Richard E. Rice	do	25.00
31	60	Hired men	do	256.11
31	61	Gottlieb Jahnke	do	25.00
31	62	Butler Brothers	Nails	6.90
31	63	Kramer & Knitter	Bolts, etc	12.37
31	64	John Jansen	Lumber	129.70
31	65	Schlafer, Barrett & Tesch	Drift bolts, etc	258.96
31	66	K. M. Hutchinson	Rope	4.20
31	67	Gillingham & Son	Lumber	6.00
31	68	McKenzie & Crawford	Coal	13.01
31	69	Ole Olson	Towing	24.00
31	70	Conlee Lumber Company	Lumber	876.75
31	71	Mitchel Garrow	Clam poles	20.00
31	72	C. A. Peck	Lye, etc	16.71
31	73	Neils Johnson	Iron, etc	111.57
31	74	Charles S. Morris	Coal	209.15
31	75	Priest & Garrow	Wood	263.90
Sept. 1	76	C. L. Neumann	Services	10.00
3	77	Hired men	Services, August, 1891	2,316.34
11	78	Swain & Tate	Paper	1.50

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Itemized statement of expenses, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1891.				
Sept. 11	79	John B. Briggs	Services	$10.50
28	80	Orville Beach	Rent of lands	25.00
30	81	Des Forges & Co	Stationery	10.67
30	82	John M. Paige	Services	30.00
30	83	Alexander Sims	do	25.00
30	84	John Baeten	do	25.00
30	85	George T. Allanson	do	30.00
30	86	George Gifford	do	25.00
Oct. 5	1	Samuel Whitney	do	200.00
5	2	John A. Banker	do	25.00
5	3	Gabriel Wick	do	25.00
5	4	Gottlieb Jahnke	do	25.00
5	5	Jerry Parkinson	do	25.00
5	6	John Lewis	do	25.00
5	7	Richard E. Rice	do	25.00
5	8	James Clear	do	30.00
5	9	Eugene Dietzgen & Co	Tracing linen, etc	21.05
5	10	Louis Clairmont	Moving stone	300.00
5	11	Hired men	Services, September, 1891	3,110.66
5	12	C. L. Neumann	do	10.00
5	13	Luther Lindauer	Mortar, etc	70.35
5	14	John Jansen	Lumber, etc	123.23
5	15	Butler Bros	Tin roofing, etc	164.54
5	16	Louis Clairmont	Moving stone	441.23
5	17	Appleton Machine Co	Iron castings, etc	3.60
5	18	A. L. Smith	Hire of house	45.00
5	19	Gerry Lumber Co	Lumber, etc	203.31
5	20	D. T. H. MacKinnon	Brass castings, etc	5.00
5	21	J. C. Koelsch	Rope, etc	6.92
5	22	W. E. Wheeler	Hauling stone	137.92
5	23	William Krueger & Co	Rope, etc	9.10
5	24	Battis Bros	Steel, etc	8.50
5	25	D. P. Sanford	Oil	10.76
5	26	Conlee Lumber Co	Lumber	27.80
5	27	Ossian Cook	Rent of office	66.00
5	28	McKenzie & Crawford	Wood, etc	407.18
5	29	C. A. Peck	Lath, yarn, etc	20.05
5	30	William Bannerman	Stone	76.00
5	31	August Swanke	Lumber	1.32
5	32	Priest & Garrow	Wood	406.00
12	33	J. D. Splaine	Services	10.00
22	34	Swain & Tate Co	Heading vouchers, etc	4.00
31	35	John M. Paige	Services	30.00
31	36	Alexander Sims	do	25.00
31	37	John Baeten	do	25.00
31	38	George Gifford	do	25.00
31	39	John A. Banker	do	25.00
31	40	Gabriel Wick	do	25.00
31	41	Gottlieb Jahnke	do	25.00
31	42	Jerry Parkinson	do	25.00
31	43	John Lewis	do	25.00
31	44	Richard E. Rice	do	25.00
31	45	James Clear	do	30.00
31	46	Louis Clairmont	Wood	104.00
31	47	Luther Lindauer	Brick	10.92
31	48	Kramer & Knitter	Screw bolts, etc	16.93
31	49	Butler Bros	Boat spikes, etc	60.10
31	50	Peter Corpes	Plastering, etc	77.71
31	51	John Jansen	Lumber, etc	80.21
31	52	Schlafer, Barrett & Tesch	Drift bolts, etc	40.00
31	53	Gerry Lumber Co	Lumber	476.25
31	54	Howard & Jennings	Labor	1.80
31	55	J. C. Koelsch	Glass, etc	3.29
31	56	Battis Bros	Labor	5.20
31	57	C. A. Peck	Lathyarn, etc	10.15
31	58	Niels Johnson	Oil, etc	17.30
31	59	E. Teske & Bro	Depositing dredged material	15.00
31	60	Otto H. Lichtenberg	Oil, etc	17.35
31	61	H. K. Priest	Stone	115.00
31	62	George T. Allanson	Services	30.00
31	63	Samuel Whitney	do	200.00
31	64	J. H. Marston & Co	Mortar	53.54
31	65	Swain & Tate Co	Heading vouchers, etc	4.75
31	66	C. L. Neumann	Services	10.00
Nov. 4	67	Hired men	Services October, 1891	2,592.59
5	68	Willie Wick	Stone	294.00
5	69	D. P. Sanford	Oil, etc	10.22
13	70	Orville Beach	Rent of land	25.00
13	71	Timothy Sullivan	Brush	3.50
13	72	Lourence Hysic	do	7.50
16	73	Mitchell Garrow	Piles, etc	583.33

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Itemized statement of expenses, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1891.				
Nov. 16	74	John Schwark	Brush	$5.60
30	75	Samuel Whitney	Services	200.00
30	76	John M. Paige	do	30.00
30	77	Alexander Sims	do	25.00
30	78	John Baeten	do	25.00
30	79	George T. Allanson	do	30.00
30	80	George Gifford	do	25.00
30	81	John A. Banker	do	25.00
30	82	Gabriel Wick	do	25.00
30	83	Gottlieb Jahnke	do	25.00
30	84	Jerry Parkinson	do	25.00
30	85	John Lewis	do	25.00
30	86	Richard E. Rice	do	25.00
30	87	James Clear	do	30.00
30	88	C. L. Neumann	do	10.00
Dec. 3	89	Samuel Whitney	Traveling expenses	10.50
3	90	Elwin Bauter	do	3.62
3	91	Hired men	Services, Nov., 1891	1,638.88
4	92	Charles M. Cole	Traveling expenses	9.94
4	93	W. M. Bambert	Labor	2.00
4	94	Jno. Jansen	Lumber	11.64
4	95	Butler Bros	Paint, etc	16.72
4	96	J. H. Marston & Co	Mortar	1.20
4	97	Schlafer, Barrett & Tesch	Paint, etc	24.75
4	98	Gerry Lumber Co	Lumber, etc	55.12
4	99	Ryan Brothers	Hauling out boat	60.00
4	100	H. Stedman	Lumber	1.56
4	101	C. A. Peck	Lath yarn, etc	18.25
4	102	Chas. S. Morris	Coal	83.54
4	103	Priest & Garrow	Wood	98.60
4	104	George Zuehls	Depositing dredged material	8.05
5	105	John Flynn	Services	8.43
9	106	Henry Weber	do	5.25
31	107	Ramsay & Jones	Lumber	793.38
31	108	John M. Paige	Services	35.00
31	109	Alexander Sims	do	35.00
31	110	James Clear	do	30.00
31	111	Gottlieb Jahnke	do	25.00
31	112	John Lewis	do	25.00
31	113	Gabriel Wick	do	25.00
31	114	George Gifford	do	25.00
31	115	Jerry Parkinson	do	25.00
31	116	John Baeten	do	25.00
31	117	John A. Banker	do	35.00
31	118	George T. Allanson	do	30.00
31	119	A. L. Smith	Hire of house	45.00
31	120	Ramsay & Jones	Lumber	873.28
31	121	Ossian Cook	Rent of office	66.00
31	122	A. Sanford Logging Tool Co	Cant hooks, etc	5.38
31	123	C. A. Peck	Sole leather, etc	3.95
31	124	Warner Hardware Co	Nails, etc	8.69
31	125	A. J. Wier	Lumber, etc	129.55
31	126	Eugene Dietzgen & Co	Tracing cloth, etc	8.56
31	127	The Keith Lumber Co	Timber	274.40
31	128	Samuel Whitney	Services	200.00
31	129	Richard E. Rice	do	25.00
31	130	Samuel Whitney	Traveling expenses	10.52
1892.				
Jan. 4	1	Jones & Laughlins, limited	Bolts	244.56
4	2	Hired men	Services, December, 1891	884.11
5	3	Elwin Bauter	Traveling expenses	7.86
5	4	E. O. Hoffmann	do	6.94
8	5	Des Forges & Co	Stationery	8.45
30	1	A. J. Weir	Lumber	40.23
31	2	John M. Paige	Services	35.00
31	3	Alexander Sims	do	35.00
31	4	George Gifford	do	25.00
31	5	James Clear	do	30.00
31	6	George T. Allanson	do	30.00
31	7	John Baeten	do	25.00
31	8	Gottlieb Jahnke	do	25.00
31	9	John Lewis	do	25.00
31	10	Gabriel Wick	do	25.00
31	11	Jerry Parkinson	do	25.00
31	12	Richard E. Rice	do	25.00
31	13	John A. Banker	do	35.00
31	14	Samuel Whitney	do	200.00
Feb. 3	15	E. O. Hoffmann	Traveling expenses	1.51
3	16	Elwin Bauter	do	10.37
4	17	Hired men	Services, January, 1892	1,655.73
8	18	Louis A. Smith	do	13.12

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Itemized statement of expenses, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1892.				
Feb. 29	19	Samuel Whitney	Services, January, 1892	$200.00
29	20	John M. Paige	do	35.00
29	21	Alexander Sims	do	35.00
29	22	John A. Banker	do	35.00
29	23	James Clear	do	30.00
29	24	Richard E. Rice	do	25.00
29	25	John Lewis	do	25.00
29	26	Jerry Parkinson	do	25.00
29	27	Gottlieb Jahnke	do	25.00
29	28	Gabriel Wick	do	25.00
29	29	George Gifford	do	25.00
29	30	George T. Allanson	do	30.00
29	31	John Baeten	do	25.00
Mar. 3	32	Hired men	do	1,602.18
9	33	Battis Brothers	Labor	6.70
9	34	Gillingham & Son	Iron, etc	10.70
9	35	K. M. Hutchinson	Iron, etc	35.50
9	36	Orville Beach	Rent of land	25.00
9	37	Lewis & Prehn	Iron bolts	19.26
9	38	A. J. Weir	Lumber, etc	66.85
9	39	H. Stedman	Lumber	14.88
9	40	Jones & Laughlins, limited	Iron bolts, etc	365.01
9	41	do	Chain	91.13
9	42	Excelsior Iron Works	Sheave, etc	44.50
18	43	Charles W. Day	Lumber	357.55
18	44	Appleton Machine Co	Iron castings, etc	171.24
18	45	Ramsay & Jones	Lumber	605.80
18	46	do	do	747.12
18	47	Conlee Lumber Co	do	246.87
29	48	Jno. Jansen	do	16.74
29	49	A. L. Smith	Hire of house	45.00
29	50	Ramsay & Jones	Lumber	56.50
29	51	Appleton Machine Co	Iron castings	112.52
29	52	K. M. Hutchinson	Iron, etc	7.10
29	53	J. H. Jenkins	Lumber	7.28
29	54	The Foote-Cornish Milling Co	Furnishing steam	7.50
29	55	Hay Hardware Co	Spikes	10.40
29	56	Gillingham & Son	Steel fender, etc	19.39
29	57	Ossian Cook	Rent of office	66.00
29	58	Stroud & Thomson	Oakum, etc	69.57
29	59	C. A. Peck	Iron, etc	11.96
29	60	John W. Slater	Oil, etc	14.90
29	61	A. J. Weir	Lumber	1.59
29	62	Warner Hardware Co	Spikes, etc	2.55
31	63	John M. Paige	Services	35.00
31	64	Alexander Sims	do	35.00
31	65	John A. Banker	do	35.00
31	66	James Clear	do	30.00
31	67	Richard E. Rice	do	25.00
31	68	John Lewis	do	25.00
31	69	Jerry Parkinson	do	25.00
31	70	Gottlieb Jahnke	do	25.00
31	71	Gabriel Wick	do	25.00
31	72	George Gifford	do	25.00
31	73	George T. Allanson	do	30.00
31	74	John Baeten	do	25.00
31	75	Samuel Whitney	do	200.00
Apr. 2	1	Des Forges & Co	Stationery	16.70
4	2	Hired men	Services, March, 1892	1,942.42
5	3	Doman & Manuel	Marine boiler	1,126.91
28	4	Ole Peterson	Services	4.50
29	5	C. A. Lawton	Iron, etc	18.43
29	6	T. M. Kellogg	Wall paper	9.97
29	7	Luther Lindauer	Sand	17.25
29	8	Butler Bros	Nails, etc	49.46
29	9	Jno. Jansen	Window frames, etc	68.91
29	10	Appleton Machine Co	Iron rollers, etc	43.10
29	11	Gerry Lumber Co	Lumber	287.12
29	12	A. Sanford Logging Tool Co	Pike poles	2.00
29	13	Hay Hardware Co	Packing, etc	12.54
29	14	Robert Brand & Son	Steering wheel, etc	27.50
29	15	Hay Hardware Co	Nails, etc	83.49
29	16	Stroud & Thomson	White lead, etc	39.74
29	17	Battis Bros	Steel, etc	44.90
29	18	Gillingham & Son	Screw bolts, etc	55.80
29	19	C. A. Peck	Soap, etc	7.85
29	20	Niels Johnson	Maple cogs, etc	43.95
29	21	do	Iron castings, etc	152.77
29	22	do	Steel castings, etc	188.51
30	23	The Morgan Co	Lumber, etc	380.09
30	24	John M. Paige	Services	35.00

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Itemized statement of expenses, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1892.				
Apr. 30	25	Alexander Sims	Services	$29.66
30	26	John A. Banker	do	30.00
30	27	James Clear	do	30.00
30	28	Richard E. Rice	do	25.00
30	29	John Lewis	do	25.00
30	30	Jerry Parkinson	do	25.00
30	31	Gottlieb Jahnke	do	25.00
30	32	Gabriel Wick	do	25.00
30	33	George Gifford	do	25.00
30	34	George T. Allanson	do	30.00
30	35	John Baeten	do	25.00
30	36	Joys Bros. & Co	Rope, etc	82.81
May 2	37	Samuel Whitney	Traveling expenses	9.34
2	38	Elwin Bauter	do	2.06
2	39	Eugene Dietzgen & Co	Tracing cloth	8.40
2	40	Doman & Manuel	Marine boiler	104.09
2	41	Excelsior Iron Works	Dipper-handle, shaft, etc	260.26
2	42	Samuel Whitney	Services	200.00
3	43	Des Forges & Co	Stationery	28.04
4	44	Hired men	Services, March, 1892	2,713.60
13	45	John Gevers	do	18.00
19	46	Burdick, Armitage & Allen	Notices of law	7.00
31	47	Hired men	Services	245.00
31	48	Samuel Whitney	do	200.00
31	49	John M. Paige	do	35.00
31	50	Alexander Sims	do	25.00
31	51	John A. Banker	do	25.00
31	52	James Clear	do	30.00
31	53	Richard E. Rice	do	25.00
31	54	John Lewis	do	25.00
31	55	Jerry Parkinson	do	25.00
31	56	Gottlieb Jahnke	do	25.00
31	57	Gabriel Wick	do	25.00
31	58	George Gifford	do	25.00
31	59	George T. Allanson	do	30.00
31	60	John Baeten	do	25.00
31	61	William Jansen	Sand	30.75
31	62	Louis Clairmont	Moving stone	579.70
31	63	Hubert Zegers	Lime	11.50
31	64	Luther Lindauer	Tile, etc	4.60
31	65	Charles Wheaton	Plastering, etc	80.13
31	66	Butler Bros	Locks, knobs, etc	25.75
31	67	Kaukauna Lumber and Mfg. Co	Lumber, etc	95.29
31	68	Schlafer, Barrett & Tesch	Nails, etc	13.60
31	69	J. H. Marston & Co	Moving stone	76.47
31	70	Gerry Lumber Co	Lumber	159.50
31	71	Julius Fieweger & Sons	Iron, etc	1.25
31	72	B. H. Soper & Co	Window shades	5.00
31	73	August Schroeder	Hire of jackscrews	7.25
31	74	Gillingham & Son	Screw bolts, etc	17.66
31	75	Hay Hardware Co	Files, etc	13.07
31	76	C. W. Johnston	Towing	18.00
31	77	Orville Beach	Rent of land	25.00
31	78	W. H. Crawford	Washout closet, etc	33.30
31	79	F. H. Josslyn	Carpet, etc	33.47
31	80	Stoud & Thomson	Oakum, etc	35.50
31	81	Doman & Manuel	Iron castings, etc	36.11
31	82	The Morgan Co	Lumber, etc	39.23
31	83	D. P. Sanford	Oil	58.71
31	84	McKenzie & Crawford	Wood, etc	63.75
31	85	Hay Hardware Co	Rope, etc	89.31
31	86	W. H. Nichols and S. E. McPartlin	Boiler covering	84.41
31	87	H. M. Harmon	Painting	94.99
31	88	Doman & Manuel	Iron castings, etc	158.77
31	89	McKenzie & Crawford	Moving stone	455.77
31	90	Doman & Manuel	Horizontal engines, etc	1,937.00
31	91	August Ziemer	Lumber	3.28
31	92	John W. Slater	Oil, etc	8.27
31	93	Niels Johnson	Packing, etc	26.81
31	94	C. A. Peck	Soap, etc	32.87
31	95	H. Stedman	Coal, etc	179.42
31	96	F. T. Yahr	Lath, yarn, etc	27.01
31	97	Priest & Garrow	Wood	423.87
31	98	C. L. Neumann	Services	10.00
June 2	99	Samuel Whitney	Traveling expenses	5.32
7	100	Des Forges & Co	Stationery	13.80
7	101	Excelsior Iron Works	Steel pinions	30.40
7	102	Hired men	Services, May, 1892	3,871.17
8	103	Maj. James F. Gregory	Mileage	17.44
10	104	Hired men	Services, May, 1892	577.88
10	105	George Zuehls	Depositing dredged material	14.00

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Itemized statement of expenses, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1892.				
June 10	106	Endre Paulson	Services	$21.09
13	107	Joys Bros. & Co.	Flag	7.50
13	108	Maj. H. M. Adams	Mileage	161.12
15	109	William Hare	Services	3.37
15	110	Gustav Pischka	do	3.75
15	111	Herman Rich	do	6.00
22	112	August Misky	do	5.31
22	113	George Cook	do	3.00
23	114	Estate of K. M. Hutchinson	Rope, etc.	26.32
23	115	do	Tin roofing, etc	178.90
24	116	John Chippie	Services	5.31
28	117	Paul Maager	do	16.50
30	118	Samuel Whitney	Traveling expenses	16.00
			Total	55,989.98

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APPENDIX J J.

IMPROVEMENT OF CHICAGO AND CALUMET HARBORS, ILLINOIS; OF CALUMET RIVER, ILLINOIS AND INDIANA; AND OF ILLINOIS RIVER, ILLINOIS; ILLINOIS AND MISSISSIPPI CANAL.

REPORT OF CAPTAIN W. L. MARSHALL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Chicago Harbor, Illinois.
2. Calumet Harbor, Illinois.
3. Calumet River, Illinois and Indiana.
4. Illinois River, Illinois.
5. Operating and care of La Grange Lock and Dam, Illinois River, Illinois.
6. Illinois and Mississippi Canal.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., August 18, 1892.

GENERAL: I have the honor to transmit herewith annual reports upon the works in my charge for the fiscal year ending June 30, 1892.

* * * * * * *

Very respectfully, your obedient servant,
W. L. MARSHALL,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

J J 1.

IMPROVEMENT OF CHICAGO HARBOR, ILLINOIS.

The present project was adopted in 1870 and modified in 1878, and contemplates—

(*a*) The formation of an outer harbor or basin by inclosing a portion of Lake Michigan just south of and adjoining the entrance to the river, for the purpose of increasing the harbor facilities of Chicago and to give relief to the overcrowded river.

(*b*) The construction of an exterior breakwater of crib work filled with stone outside the outer harbor and north of the entrance to Chicago River in deep water, to shelter the entrance to Chicago River (which constitutes the harbor of Chicago) and the outer harbor from northerly

storms, and to form a sheltered area or harbor of refuge at the southern end of Lake Michigan.

In addition to this project the entrance to Chicago River, which is protected by piers built by the United States, is to be maintained, both piers and channel.

CONDITION OF THE WORK JUNE 30, 1892.

Outer basin.—This basin, lying south and east of the present mouth of Chicago River, covers about 455 acres in area. A dock and wharf line was established by Special Order, Corps of Engineers, No. 108, August 3, 1871, and adopted and extended upon the recommendations of a Board of Engineers by the Secretary of War, September 22, 1890.

This dock line is about 1,300 feet east of the present shore line and parallel to and 2,000 feet distant from the easterly breakwater, and extends throughout the harbor from north to south.

Between the dock line and breakwater an area of 270 acres is included, which the original project contemplatnd dredging to 16 feet in depth where deficient. The area between dock line and shore is reserved for slips and docks. Two hundred and sixty-seven thousand cubic yards of material are yet to be dredged from the outer basin beyond the dock line, but as the area already dredged is sufficient for present needs, and the material is necessary for the construction of any docks and wharves in this basin, no further dredging is desirable until such use becomes apparent.

The piers inclosing this basin have been completed for years and now the only expenditures required are for maintenance.

The purposes of this outer harbor have never been realized, due to the litigation attending the determination of the question of riparian ownership and rights. No wharves and docks have been constructed, except by the Illinois Central Railroad, north of Randolph street, and the breakwaters serve only the purpose of protecting this corporate property and affording to the people of Chicago a protected and safe basin for pleasure craft. Since the construction of the exterior breakwater it has no value as a harbor of refuge.

This basin will probably never subserve its intended purpose and all expenditures for maintaining the breakwaters and piers should be reduced to a minimum and be carefully considered. At most, temporary work of timber and rubblestone should be employed until its final disposition is determined.

It is now in question to use temporarily a part of this outer harbor for the purposes of transportation by water to and from the grounds of the World's Columbian Exposition, 1893, and any further use of that part of this harbor shoreward of the harbor line established by the Secretary of War September 22, 1890, will depend upon the decision in the pending case, on appeal before the United States Supreme Court, upon the question of ownership of riparian rights and submerged lands.

At the beginning of the fiscal year work was in progress under contract dated January 5, 1891, with the Kimball and Cobb Stone Company, of Chicago, for rebuilding 5,243 feet of superstructure with pile protection, and repairs of easterly breakwater outer basin and of North Pier to the entrance to Chicago River. This work was prosecuted vigorously by the contractors and the work contracted for completed by them and the contract closed October 19, 1891, about two and one-half months in advance of the time set for its completion.

Under this contract 2,542.5 linear feet of superstructure 6 feet in height and 997.8 linear feet 8 feet in height were completed at the close of the fiscal year therefore the north pier of Chicago Harbor and the easterly breakwater and its return, 5,240.3 linear feet, are in fine order and condition.

The report of Assistant Engineer Liljencrantz herewith gives the details of the work.

The southerly breakwater, outer harbor, and the south pier at the entrance to Chicago River are in bad condition and now require renewal.

Exterior breakwater.—This work is situated 1 mile northeast of the mouth of Chicago River, the entrance to which it covers from northerly storms; it is 5,413 feet in length.

This construction was begun in 1881 and completed in 1890. The entire breakwater, except the outer 1,200 linear feet, is of crib work 30 feet in width placed on the natural bottom in water varying from 18 to 32 feet in depth. The outer 1,200 linear feet are built upon a stone foundation. This breakwater answers the purpose for which it has been constructed, and its value as forming a safe harbor of refuge during northerly storms and as affording a sheltered entrance to the harbor of Chicago is conceded by all parties interested in the commerce of this great port.

During the past fiscal year no work was done upon this breakwater, but it will soon be necessary to renew the superstructure over three-fifths of its extent, and for that purpose an estimate is herewith submitted.

Entrance to Chicago River.—The Chicago River constitutes the inner harbor of Chicago, and it has hitherto been customary to periodically dredge that part of it lying between the bridge nearest the lake and the mouth of the river at the pier heads. The last dredging was done in 1888, since which date no further dredging has been necessary, and no work has been done.

PROPOSED APPLICATION OF FUNDS NOW ON HAND, AND THOSE ASKED FOR, FOR THE FISCAL YEAR ENDING JUNE 30, 1893.

The funds now on hand will be applied to the survey of Chicago Harbor to show the completed works, the harbors created thereby, and the approaches thereto. The funds asked for are to be applied as follows: $72,000, as in the river and harbor bill now pending, to the completion of the existing project as far as advisable and to renewing superstructures over 1,225 feet of the South Pier, Chicago Harbor entrance, and over certain parts of the southerly breakwater. outer basin, and $80,000 to renewing superstructures over 3,140 linear feet exterior breakwater and necessary engineering and contingent expenses.

Money statement.

July 1, 1891, balance unexpended	$96,003.20
June 30, 1892, amount expended during fiscal year	94,393.43
July 1, 1892, balance unexpended	1,609.77
July 1, 1892, outstanding liabilities	184.76
July 1, 1892, balance available	1,425.01
Amount appropriated by act approved July 13, 1892	72,000.00
Amount available for fiscal year ending June 30, 1893	73,425.01

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Amount (estimated) required for maintenance, repair, and preservation of superstructures	$80,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	80,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit herewith a report of operations in Chicago Harbor, Ill., for the fiscal year ending June 30, 1892.

The work during the year consists in completing the building of new superstructure, 6 feet high, over the easterly breakwater, in building superstructure 8 feet high over the North Pier, in repairing damages done to the piers by vessels and in protecting the ends of the North Pier and the "return" by pier heads and by clumps of piles.

This work of superstructure over the Easterly breakwater and the North Pier and protections, etc., was done under contract with the Kimball and Cobb Stone Company, of Chicago, Ill., dated January 5, 1891.

Work under the contract commenced on May 9, 1891, and was completed on October 19 of the same year, or about two and one-half months sooner than authorized by the terms of the contract, which specified the time for expiration at December 31.

Previous to the commencement of the year, work had been completed, with the exception of stone filling and decking, for a distance of 1,700 linear feet, in which were used 749,240 feet B. M. of pine timber and 70,513 pounds of wrought-iron drift bolts.

During the year 2,542.5 linear feet of work 6 feet high and 997.8 linear feet of work 8 feet high were completed, making a total of work under the contract of 4,242.5 linear feet 6 feet high and 997.8 linear feet 8 feet high, or, in the aggregate, 5,240.3 linear feet of new superstructure.

The total amount of materials furnished and secured in the work, under the contract, and including the amounts in the 1,700 linear feet of work, reported above as completed during the previous year, was as follows:

Pine timber	feet B. M.	1,954,871
Pine decking	do	846,391
Piles, 40 feet long		253
Piles, 35 feet long		38
Wrought-iron drift bolts	pounds	189,381.4
Wrought-iron screw bolts	do	12,265
Wrought-iron spike	do	66,475
Ulster iron dredge chain	do	1,129
Cords of stone		892.13

The distribution of the above amounts of timber, drift bolts, and stone is shown on a table, respectfully submitted herewith. It will be noticed that the above amounts exceed somewhat the totals given in the table. The reason for this is that the above amounts include *all* materials furnished and paid for under the terms of the contract and include work on the two pier heads and repairs of damages to the ends of the North Pier and the "return," whereas in the table only such materials are given as belong exclusively to the superstructure proper.

This table has been computed and submitted in the belief that, being derived from work actually done, it might be found convenient and useful in the preparation of approximate estimates for similar work. The averages of so many sections of equal dimensions might be expected to furnish a fairly reliable basis for such estimates. Its general usefulness will be enhanced by the following explanations and remarks, which are also needed for a better understanding of the table:

1. All side timbers were 12 by 12 inches and in lengths to break joints so as to leave at least two unbroken timbers between any two joints in the same perpendicular line. Six courses in height would ordinarily require 1,200 linear feet of side timbers in a 100-foot section. Where, however, a top timber of the substructure was found to be in bad condition, it was replaced by a new timber, which accounts for the excess over the 1,200 linear feet in the table in some sections.

2. *Cross-ties.*—These were all 10 by 12 inches by 30 feet in length. The frequently irregular settling of the cribs in the substructure is the cause of some irregularity in the number of ties to an even 100 linear feet of the work.

The same remark will apply to the blocks.

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3. Blocks were 10 by 12 inches by 28 feet.

They were placed between the cross-ties in juxtaposition to the side walls and in vertical tiers corresponding to the end walls of the 50-foot cribs of the substructure. They were secured to the cross-ties in same manner as the timbers are in the side walls, thus forming solid walls.

4. Longitudinals were made of 10 by 12 inch timber. They were placed between the cross-ties, running continuously through the length of the work, with 16 inches long scarfs, so placed as to come between two ties, and with drift-bolts passing through the two parts of the scarf and the tie below.

5. *Shims or shimming pieces.*—Before placing the first or lowest cross-ties it was generally found that the top of the tie of the substructure was in the same plane as the top of its side timbers, leaving thus an insufficient space for the bottom longitudinals, as provided by the plans. These were therefore omitted and short blocks substituted in their places under the bottom ties. Owing to irregular settling of the substructure in most places, wedge-shaped sticks had to be resorted to frequently to secure a horizontal bearing for the new work. All these and other pieces required to remedy the effects of irregularities of the old work were counted under this head.

6. Drift-bolts were of round iron, 1¼ inches in diameter. Thirty-two-inch bolts were used in the side timbers and solid cross walls; 20-inch bolts in ties and longitudinals and partly in the top timbers of side and cross walls.

7. The decking consisted in 6 by 10 inch timbers laid lengthwise and spiked with ½ by 12 inch wrought-iron spikes to the ties.

The butt ends, most subjected to the process of decay, were protected by 3 by 12 inch plank spiked down crosswise, covering the joints.

8. *Stone filling.*—The new work was filled to within 3 feet of the top, which was considered sufficient for safety now, since these works are protected against northerly storms by the exterior breakwater.

During the progress of the work stone removed from the old work was transferred to completed portions and thus no new stone was required for the part—the northerly half of the easterly breakwater—which was first completed, and the north pier, which was finished last, required the greatest amount of new stone.

To protect the easterly end of the north pier and the westerly end of the "return," which two places had for a number of years been in a deplorable condition, from damages sustained by vessels running into them, these places were surrounded by pier heads, consisting of single closely driven rows of piles, held together with waling pieces on either side of the piles and screw bolts through both, and attached to the pier by means of 1¼-inch iron tie-rods.

The inclosure was filled with stone, and riprap was placed outside the piles to counterbalance the pressure of the stone filling. Clumps of 7 piles in each, held together by screw bolts and 2 rounds of iron dredge chain, were placed as additional protection around the pier heads just described and around the north end of the easterly breakwater. Each clump, when constructed, was surrounded by riprap to within 18 feet of the water surface.

In addition to work done under the terms of the contract some materials were furnished and secured in the work under a special verbal agreement, viz, 10,348 feet B. M. oak timber, 10 turnbuckles, and 3 piles of special length, 2 being 44 feet each and the third 43 feet long.

The oak timber was used for waling pieces in the pier heads and for snubbing posts in the north pier. The turnbuckles were used on the tie-rods in the pier heads, and the piles in the clumps.

No dredging was done during the year and none is required for the present.

Condition of the works.—The easterly breakwater and the north pier, as well as the 500 linear feet of the southerly breakwater, which were rebuilt in 1889, are now in good condition. So are the pier heads and most of the clumps of piles built during the year. One of the latter, at the end of the north pier, has been broken up, presumably by some vessel having run into it.

There is frequently found a very strong current at the different pier ends, which, the vesselmen claim, makes their boats at such times unmanageable. This is the only plausible excuse for the many collisions of this kind in times past, and the protections built during the year were much needed and are of considerable value as such.

The south pier is in extremely bad condition. The greater part of the timbers in the superstructure are rotten and numerous pieces even detached from the main work so as to allow the stone filling to issue forth into the river channel. The cribs of this work were sunk in 1869 and 1870 and the superstructure was built in the latter year, being accordingly fully 22 years old. Considering its age it has held out well, no doubt on account of not being, like the breakwaters, exposed to severe winds.

The southerly breakwater was built in 1879 to 1880. This work is 3,000 feet in length. It shows the effect of southerly or southeasterly gales and of general decay

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and needs new superstructure, with the exception of the 500 linear feet mentioned above as having been rebuilt in 1889.

The easterly portion of the exterior breakwater is as yet in fair condition, but the westerly portion, 3.140 linear feet, more or less, in length, built in 1881 to 1883, will soon require rebuilding. This is the most severely exposed of all the works and at the same time the one the substantial condition of which is of the greatest importance.

The cost of repairing these works is estimated as follows:

Superstructure exterior breakwater 3,140 linear feet, at $24	$75,360
Superstructure south pier 1,200 linear feet, at $18	21,600
Superstructure southerly breakwater 2,200 linear feet (16 feet wide), at $16	35,200
Superstructure southerly breakwater 300 linear feet (30 feet wide), at $19	5,700
Total	137,860
Add 10 per cent for contingencies, etc	13,786
Total	151,646

In the river and harbor bill at present before Congress the amount of $72,000 is provided for the completion, etc., of this harbor, which, if becoming law, will leave the amount required for maintenance of $76,646.

A tracing, showing the condition of the harbor at the close of the year, is respectfully submitted herewith.

The stage of Lake Michigan has been lower during the past year than in any previous year on record. A table is respectfully submitted herewith, giving the daily and monthly means of the gauge readings at this harbor for the year.

I am, captain, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

Readings of the gauge at Chicago Harbor, Illinois.

[Plane of reference: Chicago city datum; low water of 1847.]

Day.	1891.						1892.					
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	0.73	0.90	0.57	−0.23	0.23	−0.93	−0.27	0.07	0.53	−0.37	0.00	0.60
2	0.27	1.13	0.43	0.13	0.27	−0.54	0.97	0.03	0.13	−0.27	0.20	0.83
3	1.30	1.30	0.90	0.03	0.30	−0.17	0.27	0.20	0.04	−0.17	0.33	0.80
4	0.43	1.27	0.87	0.70	0.23	−0.76	0.13	0.07	0.10	−0.07	0.20	0.87
5	0.77	1.20	1.10	0.67	0.27	−0.67	0.03	0.66	0.07	−0.57	0.07	0.67
6	0.80	1.20	0.77	0.38	−0.67	−0.30	0.27	−0.03	−0.07	−0.20	0.50	0.40
7	0.90	1.00	0.87	0.57	−1.17	0.30	−0.13	0.07	0.10	0.00	0.73	0.73
8	1.37	1.00	0.77	0.40	−0.36	−1.10	−0.27	0.43	0.03	0.10	0.47	0.73
9	1.13	0.87	0.63	0.43	0.23	−0.87	−0.07	−0.17	−0.40	−0.20	0.37	0.60
10	0.23	1.13	0.53	0.52	0.67	−0.40	−0.17	−0.07	0.03	−0.07	0.60	0.80
11	0.43	1.00	0.63	0.67	0.67	−0.20	0.36	0.17	−0.27	0.07	0.47	0.60
12	0.63	0.83	0.70	0.40	0.53	−0.36	−0.03	0.13	0.20	0.03	0.23	0.47
13	0.77	0.43	0.63	0.23	0.23	−0.47	0.23	0.03	0.20	0.47	0.30	0.37
14	0.77	0.83	0.90	0.07	0.30	−0.33	0.30	0.63	−0.27	0.80	0.27	0.60
15	0.73	0.87	0.57	−0.33	0.13	0.53	−0.17	0.07	−0.20	0.17	0.33	0.83
16	0.67	0.60	0.43	−0.57	0.36	0.57	−0.26	−0.17	−0.03	0.07	0.17	0.37
17	0.67	0.67	0.50	−1.03	−0.97	0.13	−0.17	−0.63	0.10	0.33	0.40	0.73
18	0.80	0.93	0.43	−0.47	−1.30	0.07	0.43	0.30	−0.07	0.57	0.43	0.93
19	0.83	0.73	0.47	0.90	−1.67	0.07	0.27	0.43	−0.20	0.40	0.57	0.70
20	1.27	0.83	0.40	0.20	−0.83	0.20	−0.80	0.23	0.07	0.37	0.47	0.70
21	1.30	0.67	0.53	0.23	−0.36	−0.20	−0.63	0.07	0.10	0.23	0.50	0.90
22	1.03	0.83	0.43	0.23	0.70	−0.30	−1.00	0.06	−0.33	0.20	0.33	0.53
23	1.07	1.23	0.47	0.23	0.63	0.27	−0.36	0.10	−0.23	0.00	0.30	0.27
24	1.20	1.13	0.40	0.37	0.13	0.83	−0.43	0.07	−0.30	0.17	0.07	0.77
25	0.67	0.67	0.47	0.20	−0.13	0.10	−0.20	0.30	−0.10	0.20	0.27	0.97
26	0.93	0.57	0.50	0.13	−0.23	−0.53	−0.20	0.36	0.30	0.27	0.43	0.87
27	0.63	1.07	0.43	0.63	0.07	−0.47	−0.70	0.30	0.40	−0.07	0.13	1.17
28	0.87	0.77	−0.33	0.20	−0.10	−0.56	−0.57	0.23	−0.07	−0.20	0.30	0.83
29	0.93	0.37	0.10	−1.20	0.17	−0.03	−0.07	0.70	−0.03	−0.17	0.37	0.87
30	1.23	1.03	−0.20	−1.43	−0.40	−0.27	0.00	.....	0.17	0.17	0.33	1.03
31	0.77	1.17	.....	−1.47	.....	−0.43	−0.33	.....	0.13	.....	0.67	.....
Means	0.84	0.91	0.53	0.06	−0.69	−0.22	−0.12	0.16	0.00	0.08	0.35	0.72

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Table showing in detail the distribution of materials in rebuilding of superstructure in Chicago Harbor, 1891.

Detail sections.			Side timbers.		Cross-ties.		Blocks.		Longitudinals.			Shims, etc., feet, B.M.	Totals, feet, B.M.	Wrought-iron drift bolts.			Decking, feet, B.M.	Spike, pounds.	Stone, cords.	Cost.
Location.	No.	Length	Linear feet.	Feet, B.M.	No.	Feet, B.M.	No.	Feet, B.M.	Linear feet.	Scarfs.	Feet, B.M.			32 inches long.	20 inches long.	Pounds.				
		Feet.																		
Easterly breakwater, from the concrete work northward, 6 feet high.	1	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	2,000	35,587	325	95	3,458	14,549	1,119	.....	$1,529.70
	2	100	1,200	14,400	45	13,500	10	2,800	400	26	4,347	1,456	36,503	325	95	3,458	16,504	1,270	.....	1,609.22
	3	100	1,200	14,400	42	12,600	8	2,240	400	27	4,360	1,608	35,208	325	94	3,451	16,504	1,270	.....	1,571.46
	4	100	1,200	14,400	42	12,600	6	1,680	400	26	4,347	1,584	34,611	325	94	3,451	15,236	1,172	.....	1,519.78
	5	100	1,200	14,400	39	11,700	8	2,240	400	26	4,347	1,752	34,439	324	93	3,437	14,504	1,116	.....	1,494.58
	6	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,696	35,283	326	95	3,466	14,504	1,116	.....	1,519.92
	7	100	1,220	14,640	42	12,600	8	2,240	400	26	4,347	2,118	35,945	324	94	3,442	14,504	1,116	.....	1,538.40
	8	100	1,216	14,592	42	12,600	8	2,240	400	26	4,347	1,508	35,287	324	95	3,448	16,490	1,269	.....	1,573.28
	9	100	1,226	14,712	42	12,600	8	2,240	400	27	4,360	1,510	35,422	326	93	3,455	15,888	1,222	.....	1,561.08
	10	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,520	35,107	327	94	3,469	14,552	1,120	.....	1,516.26
	11	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,509	35,096	325	93	3,446	14,504	1,116	.....	1,513.90
	12	100	1,224	14,688	42	12,600	8	2,240	400	26	4,347	1,590	35,465	324	92	3,431	16,440	1,264	.....	1,576.53
	13	100	1,200	14,400	42	12,600	8	2,240	400	27	4,360	1,680	35,280	324	93	3,437	14,604	1,124	.....	1,521.68
	14	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,500	35,087	324	92	3,431	14,504	1,116	.....	1,513.19
	15	100	1,240	14,880	42	12,600	8	2,240	400	26	4,347	1,635	35,702	324	95	3,448	14,672	1,129	.....	1,536.08
	16	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,750	35,337	324	94	3,442	16,504	1,270	.....	1,574.93
	17	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	2,095	35,682	326	98	3,483	16,504	1,270	.....	1,586.16
	18	127.6	1,531	18,372	51	15,300	6	1,680	511	28	5,484	2,260	43,096	406	117	4,310	20,883	1,605	.....	1,944.44
Total		1,827.6	22,057	264,684	765	229,500	142	39,760	7,311	473	79,422	30,771	644,137	5,928	1,716	62,963	281,850	21,684	.....	28,200.59
Easterly breakwater, from the concrete work southward, 6 feet high.	1	102.9	1,235	14,820	42	12,600	8	2,240	404	22	4,333	1,548	35,541	323	94	3,453	16,238	1,340	10.50	1,624.24
	2	100	1,200	14,400	42	12,600	8	2,240	400	23	4,307	2,231	35,778	325	93	3,446	16,588	1,369	10.00	1,638.81
	3	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,444	35,031	326	93	3,455	16,504	1,362	10.20	1,616.02
	4	100	1,200	14,400	42	12,600	8	2,240	400	23	4,307	1,468	35,015	320	94	3,406	16,504	1,363	10.60	1,615.93
	5	100	1,200	14,400	42	12,600	8	2,240	400	23	4,307	1,480	35,027	324	95	3,448	16,504	1,362	10.40	1,616.60
	6	100	1,200	14,400	42	12,600	8	2,240	400	22	4,293	1,444	34,977	325	94	3,451	16,579	1,368	10.20	1,616.38
	7	100	1,200	14,400	39	11,700	6	1,680	400	23	4,307	1,340	33,427	326	94	3,460	16,504	1,363	14.00	1,586.80
	8	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,354	34,941	324	95	3,448	16,504	1,362	10.00	1,612.31
	9	100	1,200	14,400	42	12,600	8	2,240	400	24	4,320	1,132	34,692	322	94	3,424	16,504	1,363	9.40	1,601.70
	10	100	1,200	14,400	42	12,600	8	2,240	400	24	4,320	1,272	34,832	320	95	3,412	16,504	1,362	9.20	1,604.46
	11	100	1,200	14,400	42	12,600	8	2,240	400	21	4,280	1,176	34,696	326	95	3,466	16,579	1,368	9.70	1,606.43
	12	100	1,200	14,400	42	12,600	8	2,240	400	25	4,333	1,148	34,721	322	95	3,430	16,504	1,363	10.20	1,606.33
	13	100	1,200	14,400	42	12,600	8	2,240	400	22	4,293	1,194	34,727	324	95	3,448	16,504	1,362	10.40	1,607.90
	14	100	1,200	14,400	42	12,600	8	2,240	400	24	4,320	1,392	34,952	323	93	3,428	16,504	1,363	10.30	1,613.41
	15	100	1,200	14,400	42	12,600	8	2,240	400	25	4,333	1,064	34,637	324	96	3,455	16,504	1,362	10.50	1,605.95
	16	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,060	34,647	322	93	3,419	16,504	1,363	10.00	1,602.95
	17	100	1,200	14,400	42	12,600	8	2,240	400	26	4,347	1,352	34,939	324	95	3,448	16,504	1,362	11.00	1,616.75
	18	100	1,200	14,400	42	12,600	8	2,240	400	25	4,333	1,040	34,613	324	94	3,442	16,504	1,363	10.20	1,603.55

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Table showing in detail the distribution of materials in rebuilding of superstructure in Chicago Harbor, 1891—Continued.

Detail sections.			Side timbers.		Cross-ties.		Blocks.		Longitudinals.			Shims, etc., feet, B. M.	Totals, feet, B.M.	Wrought-iron drift bolts.			Decking, feet, B. M.	Spike, pounds	Stone, cords.	Cost.
Location.	No.	Length.	Linear feet.	Feet, B. M.	No.	Feet, B. M.	No.	Feet, B. M.	Linear feet.	Scarfs.	Feet, B. M.			32 inches long.	20 inches long.	Pounds.				
		Feet.																		
Easterly breakwater, etc.—Continued.	19	100	1,200	14,400	42	12,600	8	2,240	400	24	4,320	1,226	34,786	323	94	3,433	16,252	1,341	10.05	$1,600.70
	20	100	1,200	14,400	42	12,600	8	2,240	400	25	4,333	2,478	36,051	325	94	3,451	15,904	1,313	10.15	1,628.90
	21	112	1,344	16,128	48	14,400	12	3,360	448	26	4,827	2,401	41,116	354	102	3,757	17,838	1,473	11.45	1,843.63
Total		2,114.9	25,379	304,548	885	265,500	170	47,600	8,452	505	91,254	30,244	789,146	6,826	1,987	72,560	347,034	28,647	218.45	34,069.75
Return, 6 feet high.	1	100	1,200	14,400	42	12,600	8	2,240	400	22	4,293	3,049	36,582	325	94	3,451	16,564	1,254	.....	1,612.10
	2	100	1,200	14,400	42	12,600	8	2,240	400	24	4,320	1,427	34,987	324	93	3,437	16,560	1,254	20.00	1,655.33
	3	100	1,200	14,400	42	12,600	8	2,240	391.4	24	4,234	1,488	34,962	324	93	3,437	16,584	1,258	24.53	1,675.72
Total		300	3,600	43,200	126	37,800	24	6,720	1,191.4	70	12,847	5,964	106,531	973	280	10,325	49,708	3,766	44.53	4,943.15
North pier, 8 feet high.	1	97.8	1,587	19,044	56	16,800	9	2,520	576.6	34	6,219	1,280	45,863	421	117	4,444.2	16,154	1,218	34.05	2,053.00
	2	100	1,600	19,200	56	16,800	12	3,360	600	35	6,467	1,744	47,571	454	114	4,724.4	16,504	1,245	25.32	2,081.13
	3	100	1,600	19,200	56	16,800	12	3,360	600	34	6,453	1,594	47,407	454	114	4,724.4	16,504	1,245	24.18	2,071.24
	4	100	1,600	19,200	52	15,600	12	3,360	600	35	6,467	1,958	46,585	454	114	4,724.4	16,504	1,245	24.05	2,046.81
	5	100	1,600	19,200	56	16,800	12	3,360	600	34	6,453	2,495	48,308	454	114	4,724.4	16,504	1,245	14.00	2,051.56
	6	100	1,600	19,200	56	16,800	9	2,520	600	34	6,453	1,787	46,760	422	118	4,458.8	16,504	1,245	14.84	2,002.48
	7	100	1,600	19,200	56	16,800	3	840	600	33	6,440	1,476	44,756	358	126	3,927.6	16,420	1,239	12.42	1,915.28
	8	100	1,600	19,200	52	15,600	.....	.....	600	33	6,440	1,698	42,938	326	130	3,662	16,324	1,231	22.50	1,897.33
	9	100	1,600	19,200	56	16,800	.....	.....	600	32	6,427	1,483	43,910	326	130	3,662	16,504	1,245	23.10	1,933.10
	10	100	1,775	21,300	48	14,400	6	1,680	587	34	6,323	3,852	47,555	390	122	4,193.2	16,053	1,210	22.20	2,038.46
Total		997.8	16,162	198,944	544	163,200	75	21,000	5,963.6	338	64,142	19,367	461,653	4,059	1,199	43,245.4	163,975	12,368	216.66	20,090.39
Totals: Easterly breakwater and return		4,242.5	51,036	612,432	1,776	532,800	336	94,080	16,954.4	1,048	183,523	66,979	1,489,814	13,727	3,983	145,848	678,592	54,097	262.98	67,213.49
Grand total		5,240.3	67,198	806,376	2,320	696,000	411	115,080	22,918	1,386	247,665	86,346	1,951,467	17,786	5,182	189,093.4	842,567	66,465	479.04	87,303.88
Averages: Easterly breakwater, per 100 linear feet		.....	1,203	14,435.7	41.86	12,558.6	7.92	2,217.6	399.6	24.7	4,325.8	1,578.7	35,116.4	323.56	93.88	3,437.8	15,995	1,275.1	6.20	1,584.30
North pier, per 100 linear feet		.....	1,620	19,437.2	54.52	16,356	7.52	2,104.6	597.7	33.9	6,428.4	1,941.0	46,267	406.80	120.17	4,334	16,434	1,239.5	21.71	2,013.47

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COMMERCIAL STATISTICS.

Amount of revenue collected at nearest port of entry (Chicago) during fiscal year, $6,673,940.17.

Arrivals and clearances of vessels during the year, port of Chicago.

	Arrived.		Cleared.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	5,222	3,581,859	5,351	3,702,645
Sail	3,768	1,123,788	3,815	1,144,157
Total	8,990	4,705,647	9,166	4,846,802

Receipts and shipments by lake during calendar year 1891.

Receipts:	Tons.
Coal	1,246,106
Iron and iron ore	90,871
Stone	12,590
Hay	2,510
Lumber	2,746,219
Flour, salt and sugar	132,032
Cement	26,441
Potatoes	6,613
Miscellaneous merchandise	281,956
Total	4,545,338

Shipments:	Tons.
Flour	172,150
Grain	2,061,251
Lard	21,463
Meats	3,036
Lead	70,028
Seed	155,196
Oil and oil cake	36,013
Hay	9,647
Iron	4,077
Miscellaneous merchandise	136,566
Total	2,669,427

J J 2.

IMPROVEMENT OF CALUMET HARBOR, ILLINOIS.

The object of this work is to provide a deep entrance to Calumet River and the port of South Chicago, Ill.

This is effected in the usual manner by dredging a channel and protecting the dredged area by parallel piers, 300 feet apart, projecting into the lake from the river's mouth.

CONDITION OF THE WORK JUNE 30, 1892.

Work was begun on this harbor in 1870, and at the beginning of the fiscal year 2,020 linear feet of the south pier, and 3,640 linear feet of the north pier had been constructed, which completed the existing project as far as pier work is concerned, but the south pier should be prolonged 800 feet to protect the channel from drifting sands.

On account of the present urgent necessity for maintaining the work already done, the superstructure of the piers being rotten over an extent of 2,300 linear feet and in bad condition over 600 feet in addition, the estimate herewith submitted is entirely for maintenance, and contemplates no further extension of piers at the present time.

The river and harbor act of September 19, 1890, appropriated $20,000 for this work, and at the beginning of the fiscal year work was in progress under contract with W. A. McGillis & Co., of South Chicago, Ill.,

for dredging the channel between the piers to a width of 250 feet and a depth of 16 feet below extreme low water in Lake Michigan.

During the fiscal year ending June 30, 1892, the work under this contract was completed, and a channel 250 feet in width and 16 feet in depth below extreme low water in Lake Michigan, connecting deep water in Lake Michigan with the improved part of Calumet River, was secured.

During the year 57,930 cubic yards of material was dredged and removed.

In addition to the dredging done by the United States, the Illinois Steel Company continued the dredging for a practicable width for their ore vessels, and to a depth of 20 feet from the lake to their slip.

The importance of this harbor is rapidly increasing as a consequence of the dredging of the Calumet River by the United States, now in progress, which is making more desirable for manufacturing purposes the lands along its banks heretofore denied access by lake vessels.

Manufacturing establishments, elevators, etc., of magnitude are seeking this region, and the wonderful growth of Chicago and vicinity amply justifies all expenditures upon this harbor, which must necessarily supplement the crowded Chicago River.

There are influences at work that will either diminish the uses of the Chicago River and increase the demands upon the Calumet Harbor and River, or else require the thorough enlargement and rectification of the Chicago River to accommodate the enormous commerce now dependent upon the navigation of that stream. It is probable, then, that the Calumet Harbor will rapidly become one of the most important upon Lake Michigan, and should continue to receive the consideration that its position demands.

PROPOSED APPLICATION OF FUNDS ASKED FOR, FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

It is proposed to apply the funds now on hand and those asked for for the fiscal year ending June 30, 1894, in making a survey of the work already completed; to show the location, character, and effects of the completed works and approaches of this harbor; and to rebuilding superstructures and maintaining the piers and revetments protecting the entrance to the Calumet River.

A report herewith by Assistant Engineer G. A. M. Liljencrantz gives in detail the work done during the past fiscal year and the needs of this harbor and present condition of the work.

Money statement.

July 1, 1891, balance unexpended	$20,930.54
June 30, 1892, amount expended during fiscal year	12,474.59
July 1, 1892, balance unexpended	8,455.95
Amount appropriated by act approved July 15, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	23,455.95
Amount (estimated) required for maintenance	36,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	36,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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Abstract of contracts for improving Calumet Harbor, Illinois, in force during the fiscal year ending June 30, 1892.

Name and address of contractor.	Nature of contract.	Date.	To expire.	Contract extended to—
W. A. McGillis & Co., South Chicago, Ill.	Dredging 90,000 cubic yards at 13½ cents per cubic yard.	Dec. 10, 1890	Aug. 31, 1891	Nov. 30, 1891

Contract completed October 16, 1891.

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit herewith a report of operations in Calumet Harbor, Illinois, during the fiscal year ending June 30, 1892.

The work done during the year consisted in continuing dredging between the harbor piers, to a depth of 17 feet below the United States harbor datum, under contract with W. A. McGillis & Co., of South Chicago, Ill., dated December 10, 1890, at the rate of 13½ cents per cubic yard.

Work under the contract commenced on the 27th of April, 1891, and was completed on the 16th of October following.

Since the beginning of the fiscal year, 57,930 cubic yards of material were removed from the channel, which, together with the 29,087 cubic yards removed during the time from April 27 to June 30, 1891, or in all 87,017 cubic yards, constituted the total amount of material dredged under the contract.

The work was done with the contractors dipper dredge *A. B. Stetson*, a strong and powerful machine, with a dipper of 2¼ cubic yards capacity. It was built two years ago.

The total time devoted to this contract was 129.8 working days of 10 hours each, or 1,298 hours.

Out of these 1,298 hours, 1,024 hours 20 minutes were spent in actual work, the balance, 273 hours 40 minutes representing time lost on account of repairs to plant, bad weather, and other causes. The proportion of time utilized and time lost to the available time is accordingly:

	Hours.	Per cent.
Time of actual work	1,024⅓ =	78.92
Time lost	273⅔ =	21.08
Available time	1,298 =	100.00

The average daily work amounted to 87,017 ÷ 129.8 = 670.4 cubic yards.

A total of 87,017 cubic yards having been dredged in 1,024⅓ hours of "actual work" indicated a capacity of this dredge of 84.95 cubic yards per hour, or 849.5 cubic yards per day of 10 hours of uninterrupted work.

The contract should have expired on the 31st of August, 1891, but an extension of time to the 30th of November of the same year, was, at the request of the contractors in letter dated August 31, granted by the Chief of Engineers, U. S. Army, on the 8th of August, 1891.

The channel has now, as indicated on a map respectfully submitted herewith, a depth of at least 17 feet below the United States harbor datum, and a width of 250 feet.

From the Illinois Steel Company's slip eastward to Lake Michigan, periodical dredging has been done by the Steel Company, at their own expense, to secure a sufficiently deep channel for the heavily laden ore vessels entering the slip at their works.

No work was done during the year, for want of funds, to the westerly ends of the two piers, but this is very much needed. Neither was any new work done in extension of the south pier, as per project heretofore submitted.

Condition of the piers.—The stone filling placed in the outer, more exposed portions of both the piers in 1888 is yet in very good condition, having settled but slightly.

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The old revetment as well as the superstructure over the cribs of the westerly ends of both piers is becoming more dilapidated every year. The condition of these piers in general is indicated in the following table:

Conditions, etc.	North pier.	South pier.	Totals.
	Feet.	*Feet.*	*Feet.*
In good condition	1,586	500	2,086
In fair condition	300	.....	300
In bad condition	387	250	637
In worthless condition	1,242	1,040	2,282
Removed to build slips	125	230	355
Total linear feet of work	3,640	2,020	5,660

The amount of worthless superstructure being further increased during the year calls for a revised estimate of cost of needed repairs as follows:

1,962 linear feet of new superstructure at $15.34	$30,097.08
320 linear feet of sheet piling at $8	2,560.00
	32,657.08
Add 10 per cent for contingencies, etc	3,265.70
Total	35,922.78

The Illinois Steel Company, north of the harbor entrance, have increased their plant by the addition of a new plate mill of large dimensions, for the manufacture of steel plate for shipbuilding and other purposes, and the importance of this harbor is further more vividly demonstrated by the great activity in the immediate vicinity in various ways, such as in raising the grade of a number of the streets as much as from 5 to 6 feet, in the building of new lines of electrical railroads, and in the erection of numerous large and handsome brick and stone buildings for business purposes, etc.

Soundings, showing the result of the year's dredging between the harbor piers, were taken by Mr. Paul Heinze, overseer, and are shown on a map submitted herewith.

A map showing the harbor in general, and the adjoining harbor and works of the Illinois Steel Company, is also submitted.

I am, Captain, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Amount of revenue collected at nearest port of entry (Chicago) during year $6,573,940.17.

Arrivals and clearances of vessels.

	Entered.		Cleared.	
	No.	*Tons.*	*No.*	*Tons.*
Steam	749	944,837	647	807,894
Sail	329	120,350	299	103,109
Total	1,078	1,065,187	946	911,003

Showing an increase over 1890 of 218 arrivals, and 357,517 tons, of 145 clearances and 276,778 tons.

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Receipts and shipments by lake during the calendar year 1891.

Receipts:	Tons.	Shipments:	Tons.
Coal	113,880	Grain	50,815
Iron and iron ore	977,626	Steel rails	1,872
Stone	4,088	Flax seed	4,000
Salt	54,216		
Cement	5,193	Total	56,687
Lumber	813,810		
Miscellaneous	41,251		
Total	2,010,064		

J J 3.

IMPROVEMENT OF CALUMET RIVER, ILLINOIS AND INDIANA.

The object of this work as far as yet authorized is to secure a channel 16 feet deep below United States harbor datum or ordinary low water in Lake Michigan, and 200 feet wide at bottom, from the mouth of the river to one-half mile east of Hammond, Ind., to increase the facilities for handling the rapidly growing commerce of this region and to afford relief to the overcrowded port of Chicago.

The history of the work is given in previous reports of the Chief of Engineers prior to 1890, and a resume of the provisions of the river and harbor acts of July 5, 1884, August 5, 1886, and August 11, 1888, under which work was inaugurated on this river, will be found on page 2142, Report of the Chief of Engineers for 1889.

Although the project contemplates the ultimate attainment of 16 feet depth of navigation over a width of 200 feet from the mouth of the Calumet River at Calumet Harbor to a point one-half mile east of Hammond, Ind., it will be seen from the acts cited that this stretch has heretofore been divided into two sections:

(1) From the mouth to the forks of Calumet River.

(2) From the forks of the Calumet (outlet to Calumet Lake) to one-half mile east of Hammond, Ind.

For the past two years no work has been done on the second section, or between the "forks of the Calumet and one-half mile east of Hammond," and much of that done in previous years near Hammond has been worse than useless as it has been filled up by refuse from slaughter houses and manufacturing establishments.

At the close of the last fiscal year work was in progress under a contract with Wheeler & Purcell, of Portsmouth, Ohio, and 72,111 cubic yards had been removed under this contract.

This contract, which originally expired November 30, 1891, was extended from time to time to August 1, 1892, and the work under it was completed June 30, 1892. In all, 365,719 cubic yards were removed from the limits of the channel under this contract, of which 293,608 cubic yards were removed during the fiscal year ending June 30, 1892.

Up to the close of the fiscal year ending June 30, 1892, 1,137,456 cubic yards of material have been removed from the channel, making a complete channel 3 miles and 345 feet to the full width of 200 feet at bottom and 16 feet in depth, with the exception of about 9,000 cubic yards more or less of hardpan and rock still to be removed over a short section near One hundred and thirteenth street.

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The details of the work and the cost per mile thereof are given in the subjoined report of Assistant G. A. M. Liljencrantz, herewith, to which reference is respectfully invited.

During the past fiscal year the work has been impeded by two causes:

(1) On motion of A. A. Westengard to restrain further dredging over certain submerged lots claimed by him, part of which as platted extended under the deepest navigated channel of the Calumet River, and all of which are submerged at the mean level of Lake Michigan; and

(2) To the unexpected encountering by the dredges of hardpan and rock within the limits of the proposed channel.

The former cause of delay was foreshadowed (see Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1891) by an ejectment suit process served April 22, 1891.

Immediately upon service of notice of this ejectment suit, further dredging in the vicinity of the lots claimed was stopped and the dredges removed to points where no contention existed, and on June 13, 1891, the case was submitted by the officer in charge to the Chief of Engineers with the request that it be referred to the Department of Justice, and that this Department should defend the contractor's agents and the United States officers in that suit. The case was in due course referred to and undertaken by the Department of Justice, and the district attorney for the northern district of Illinois directed to defend the interests of the United States. On August 26, 1891, Mr. Thomas E. Milchrist, United States district attorney for the northern district of Illinois advised the officer in charge that the contractors had not entered upon the lands claimed by Westengard when the suit was commenced, and further advised that the suit be disregarded and that work should progress. This letter was referred to the Chief of Engineers on the same day, requesting authority to resume dredging over the disputed ground. On August 31, 1891, the Chief of Engineers directed the officer in charge in substance to resume operations and prosecute the same unless stopped by further legal process. Dredging over the disputed ground was accordingly resumed in due season, but on November 21, 1891, a notice was received of a bill of injunction restraining the agents of the United States from further dredging lands claimed by Westengard, and other relief. The case came up November 23, 1891, before Judge Tuley, of the circuit court of Cook County, Ill. Judge Tuley, after reading the bill of complaint, etc., rejected the application and refused the injunction on the ground that the United States had never parted with the title to the land claimed by Westengard, as the Calumet was a meandered stream, and the land in dispute within the meandered boundaries of the Calumet River, which is a navigable stream of the United States, can be improved for navigation to any extent within its boundaries, for the purposes of navigation, by direction of the Congress of the United States. Judge Tuley further stated that the title of Westengard as the riparian owner was good against all but the United States, the original owner and seller, and the State of Illinois, the owner of the submerged lands, but that the United States by establishing and indicating the boundaries of the Calumet River reserved, under its constitutional powers, the power to improve this navigable river anywhere within its meandered boundaries. This is essentially the position that has been taken by the officers of the Department of Justice, and is an important decision, as much of the improvement of this river, as well as others, is affected thereby.

In accordance with this decision all of Westengard's claimed lots

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lying within the approved dock lines have been dredged out and the channel improved, and it is understood that the ejectment suit has been abandoned.

(2) Under the specifications to the contracts heretofore made it has been stated that the material to be encountered is mud, sand, and clay. As the dredging progressed, however, the clay became more and more tenacious, until finally it became so hard as apparently to require blasting for its removal. Solid rock, apparently part of a narrow reef crossing the channel, was also encountered. After repeated vain attempts to remove this material, a supplementary agreement was made June 10, 1892, by authority of the Secretary of War, by which the original agreement was modified so far as to require the contractors to excavate the dredgeable material only, within the proposed channel way. Under this supplementary agreement a section of the channel 650 feet in length is not excavated to the full width and depth, but there is a channel 15 feet in depth at shoalest and narrowest point, 80 feet in width, the remainder of the 200-foot wide channel being from 11 to 16 feet in depth, as shown upon the map accompanying this report. This channel is sufficient for all present requirements of navigation on this river and for probably many years in the future. The amount of hardpan and rock so far revealed is too small to justify special appliances or contracts for its removal, and in the further prosecution of the work it seems advisable to continue the dredging of all dredgeable material, to accurately define the hardpan and rock within the proposed channel. If further material requiring blasting be discovered contracts may be made based upon definitely known material and definite quantities. It is not believed that the rock and hardpan is of great extent, but it is more advantageous to the work to uncover it by dredging than to attempt to locate the limits of probably small areas of hard material by expensive borings indefinitely multiplied over such an extent of channel. It will be recommended, therefore, that future contracts shall cover only dredgeable material, or such that may be removed without explosives, until a sufficient amount of hard material to justify special appliances for its removal is discovered, or it is definitely ascertained that the amount now in sight covers all such material to be removed.

The improvement of this river is attended by a gratifying increase in the commerce of the port of South Chicago and by the rapid increase of manufacturing and shipping interests along its borders, and the influences at work demanding either a radical widening and deepening of (as well as other entrances to) Chicago River, which constitutes the inner harbor of Chicago, or a diminution of its commerce by water, seem to point to a still more rapid development of the uses of Calumet Harbor and River for commerce by water.

For several previous years the returns of the collector of customs have indicated an annual increase in the tonnage of the port of South Chicago of about 30 per cent per annum. During the past fiscal year these returns indicate an increase of 47 per cent in tonnage, but only about 21 per cent in the number of arrivals and departures of vessels, which clearly indicates the value and effect of the increased depth of channels provided in the harbor and river, especially by increasing the size and draft of vessels trading here. Much of this increase, however, is due to the great improvements in plant and otherwise of the Illinois Steel Company's works near the mouth of the Calumet and to the construction of their own harbor north of the entrance to the Calumet River, by which increased facilities for handling ores shipped by water have been attained.

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PROPOSED APPLICATION OF FUNDS ASKED FOR, FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

It is proposed to apply these funds to the furthering towards completion of the approved project by dredging the authorized channel.

Money statement.

July 1, 1891, balance unexpended	$44,401.37
June 30, 1892, amount expended during fiscal year	34,892.76
July 1, 1892, balance unexpended	9,508.61
July 1, 1892, amount covered by uncompleted contracts	9,217.24
July 1, 1892, balance available	291.37
Amount appropriated by act approved July 13, 1892	75,000.00
Amount available for fiscal year ending June 30, 1893	75,291.37
Amount (estimated) required for completion of existing project	745,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Abstract of contracts for improving Calumet River, Illinois and Indiana, in force during the fiscal year ending June 30, 1892.

Name and address of contractor.	Nature of contract.	Date.	To expire.	Contract extended to—
Wheeler & Pursell, Portsmouth, Ohio.*	Dredging 365,000 cubic yards, at 12¼ cents per cubic yard.	Dec. 10, 1890	Nov. 30, 1891	Aug. 1, 1892
Do	Supplementary to contract dated December 10, 1890. Relief from further removing undredgeable material.	June 10, 1890	Aug. 1, 1892	

* Contracts completed June 30, 1892.

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit herewith a report of operations in Calumet River, Illinois and Indiana, for the fiscal year ending June 30, 1892.

The work during the year consisted in continuing the enlargement of the river channel between One hundred and eighth and One hundred and thirteenth streets to a width of 200 feet and a depth of 16 feet, in accordance with project approved and under contract with Messrs. Wheeler & Purcell, of Portsmouth, Ohio, dated December 10, 1890.

According to the terms of the contract this was to have expired on November 30, 1891, but at the requests of the contractors in letters dated, respectively, October 27, 1891, and May 17, 1892, extensions of time were granted, first to June 1 and finally to the 1st of August of this year.

The work under the contract was completed on the 30th of June, 1892, or at the very close of the fiscal year.

There have been removed under the terms of the contract 365,719 cubic yards of material, of which 293,608 cubic yards were removed during the fiscal year.

Since the beginning of the improvement 1,137,456 cubic yards have been removed, making a completed channel 3 miles and 345 feet in length. The total cost of dredg-

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ing this channel, exclusive of superintendence and all incidental expenses, was $135,479.68, making an average cost per mile of $44,197.42.

The work under the last contract has proved a very unprofitable one for the contractors, partly on account of the loose, slushy material from the marshes adjacent to the channel running into completed sections of the same, requiring repeated dredging in the same place, frequently two and three times after having been completed to full depth, and partly by the interference of one A. A. Westengard, who brought suit against the contractors *et al.* for trespass on his alleged property, a great portion of which was located in the natural river bed and covered by 12 feet of water at a low-water stage of the river.

The greatest drawback, however, was the encountering of a stretch of hardpan with, in some places, underlying rock, which was found in the neighborhood of One hundred and twelfth street and for a distance of 800 feet along the channel. For about one-half of this distance, the northerly half, the hardpan reached across the full width of the channel, diminishing gradually in extent southward.

The hardpan was struck at an average depth of 12 feet below the United States harbor datum, underlying rock being found in patches, rather irregular both in depth and width.

The contractors labored faithfully with the removal of the hardpan, applying every method that could be devised and applied to either the elevator or the dipper dredge engaged in this work, but with the most discouraging results. The machinery on both of these dredges was repeatedly broken, and much more time was at one period spent in repair of machinery than in doing actual work, until finally the contractors asked, in a letter dated May 5, 1892, to be relieved from removing the rock and hardpan found in the section covered by the contract, which request was granted by the honorable the Secretary of War on the 4th of June following.

An examination of the bottom of the river, to ascertain as near as practicable the amount of rock and hardpan to be found within the limits of the area contracted for, was made in April by Mr. Paul Heinze, overseer.

Results indicated the existence of 1,332 cubic yards of rock and 14,459 cubic yards of hardpan. The hardpan was extremely hard to penetrate with the pointed steel rod used for the purpose, and it was only with the utmost exertions that it could be again extracted.

The comparatively low price at which the dredging was done, 12¼ cents per cubic yard, made the difficulties encountered by the contractors felt all the more.

After being relieved of the removal of rock and hardpan, the contractors have been engaged in excavating the overlying strata of mud, sand, and clay. Even this work has been expensive. The elevator dredge did the greater part of this work, but, the hardpan being impenetrable by the spud of that dredge, around which it revolves when working, it was found necessary to make use of the dipper dredge for the sole purpose of holding it in position while working.

After increasing the strength of and otherwise modifying various parts of the elevator dredge, as has been from time to time suggested by the experience of two years' working, this dredge has done very good work.

It is unfortunately impossible, however, to present any data indicating its actual capacity, for the following reasons:

The two dredges have worked at times alternately, at other times simultaneously, in some one section of the river. The material removed has been measured "in place" and not in scows, in which latter case, if used, the work done by each dredge could have been estimated separately.

The loose material running into a completed portion of the channel to a very great extent has necessitated (1) the redredging of such portion on some occasions as often as two to three times, the dredge thus handling the same material several times, and (2) the dredging to a depth of generally not less than 2 feet below that specified in the contract, to make sure of leaving the required depth at the completion of a section reported for examination. Besides these reasons it may also be stated that frequently, after the material along the sides of the projected channel had been removed by the elevator dredge, the dipper dredge was employed in transferring the material from the center of the channel to the excavated trenches on the sides, whence it was afterwards rehandled by the former dredge, which, by means of a long conveyor and a powerful stream of water, would remove it far enough beyond the channel lines to prevent its returning into the completed channel.

In view of the experience of the last year, it is reasonable to expect that no such low bids for dredging in this river will be obtained as has been heretofore, unless some suitable provision is made in the next specifications, which will hold the contractor free from excessive loss, should rock and hardpan be encountered again, which, though not probable according to appearances, still must be (and certainly by future bidders will be) considered as possible.

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The improvement of the river has steadily increased the interest taken in it by promoters of enterprises of different kinds and magnitude, who have either planned the establishment of new works or the more advantageous location for works already in existence elsewhere.

Among the more prominent of works which have been either completed or merely started along the river during the year are as follows:

The National Smelting Company's works, at the mouth of the river, mentioned in last year's report. They are now in active operation, producing gold, silver, and lead from base bullion and ore. The company employs 125 men, and claims to do a business averaging $1,000,000 per month.

The Counselman Elevator, just completed, has a capacity of 1,250,000 bushels, and is provided with the best machinery made for the purposes intended.

It is located on the west side of the river, a short distance from the Ninety-second Street Bridge, and is so arranged that it can receive or deliver grain from or to either vessels in the slip, specially built lately by the owner, or railroad cars on the tracks leading to it from the trunk roads of that locality.

The Iroquois blast furnaces, located between Ninety-fifth street and the three railroads at South Chicago, commenced work on September 21, 1891. They employ about 500 men in one furnace and one steel plant. The output to the end of the fiscal year was 75,000 gross tons, and it is expected to average 6,000 tons per month.

The Chicago Shipbuilding Company, about 1 mile up the river, has built, since established, one steel steam yacht of 25 tons burden, and two steel steamers, *Maritana* and *Cadillac*, of respectively 2,800 and 1,268 tons. Another steel steamer of about 2,400 tons is at present under construction.

This company has also commenced the construction of a dry dock 400 feet long and 100 feet wide, with 16 feet depth of water, to be completed next winter, and a steel derrick of 100 tons capacity, which is to be finished in September next.

The Western Plaster Works, at the third of the South Chicago Dock Company's slips, manufacture calcined and land plaster from rock brought by vessels from their own quarries in Michigan. They make 800 barrels of stucco per day, and expect to handle from 40,000 to 50,000 tons of rock this season. They supply the greater portion of the stucco used in making staff for the buildings of the World's Columbian Exposition. Their mills and storage sheds occupy about 180,000 square feet.

The land on the south side of Cummings Slip and the construction of docks in front thereof are being negotiated for with a view to the establishment of extensive linseed-oil works at this place.

Chemical works have been established further up the river, near the Chittenden bridge.

At the city of Hammond, Ind., great activity has been displayed during the year, but much complaint is made by tugmen and others on account of the insufficient depth of water at certain places in the river. This condition has been greatly aggravated by the systematic dumping of manure and other refuse from the Stein, Hirsch & Co.'s starch factory into the river channel, about half a mile west of the State line, which not only fills up the channel, but makes the water in the river highly offensive and so filthy that tugs cannot use it in their boilers.

The nail mill at Hammond has doubled its capacity and manufactures now 2,000 kegs of nails daily.

A steel plate mill is under construction about one-quarter of a mile east of the nail mill. It will be in running order before the month of December and will employ from 1,000 to 2,000 hands. The works will occupy about 15 acres of land, fronting on the river, and will, if found practicable, receive their ore by water.

Even as far up the river as at the Gibson bridge, about 3 miles east of Hammond, there are nearly completed chemical works of extensive dimensions.

Two lumber yards at Hammond supply the demand of that place, which is considerable, but owing to the deficiency in depth of the river channel, already alluded to, all the lumber has to be brought by rail.

The commercial importance of Calumet harbor and river has been officially recognized by the Chicago city authorities in the establishment of a permanent station for the fire tug *Chicago*, Engine Company No. 58, at the Ninety-fifth Street Bridge, with Capt. Wm. J. Sweeney in charge, and a crew of 1 lieutenant, engineers, pilots, stokers, and pipemen, numbering 9 in all.

A map showing the river as far as improved to date, and another map showing, by soundings taken after completed dredging, the result of the work done during the fiscal year, are respectfully submitted herewith.

All surveys of the river during the year have been made by Mr. Paul Heinze, overseer, and Mr. Stephan Creutz has been employed as the local inspector. Both these gentlemen have rendered efficient and valuable services.

I am, captain, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

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COMMERCIAL STATISTICS.

As the Calumet river and harbor are so closely connected in their commercial relations, no commercial statistics are given in this place, but will be found under the head of Calumet Harbor. There is practically no navigation on the river beyond that at the harbor. As soon, however, as the river channel is opened by dredging, navigation and business along the river will develop very fast. It awaits only this opening.

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IMPROVEMENT OF ILLINOIS RIVER, ILLINOIS.

The ultimate object of this improvement is to furnish a through route of transportation by water from the southern end of Lake Michigan to the Mississippi River, of sufficient capacity for its navigation by the largest class of Mississippi River steamboats that can reach the mouth of the Illinois River.

The dimensions that have been adopted for the locks to meet this requirement are:

	Feet.
Length of lock chamber	350
Width of chamber	75
Depth at low water over sills	7

The project now under execution is for the improvement of the lower section of this route, extending from the mouth of Copperas Creek to the Mississippi River, a distance of 137 miles. Another section of the river, 88 miles in length, from the mouth of Copperas Creek to La Salle, has been improved by the State of Illinois by the construction of two locks and dams, one at Copperas Creek and one at Henry, Ill.

Over this latter section the State still collects tolls, the United States not yet having accepted the conditions imposed by the act of cession of the Illinois legislature, which conditions are such as to deprive the works of all value while demanding a great expenditure by the United States Government for works to be substituted therefor.

With regard to this subject reference is made to the Annual Report of the Chief of Engineers for 1889, page 2121, *et sequitur*.

Under the act of Congress of August 11, 1888, surveys and separate estimates have been made, based upon low-water depths of 8 and 14 feet, for carrying the improvement from La Salle to Lake Michigan via the Illinois and Desplaines Rivers, and a cut across the Chicago divide, over which section there is a fall in water surfaces, Lake Michigan being the summit, of about 141 feet.

The report upon this survey and estimates has been printed as House Ex. Doc. No. 264, Fifty-first Congress, first session, and is also published in the Annual Report of the Chief of Engineers for 1890, page 2419 and following pages.

Other surveys and estimates have also been made by the trustees of the sanitary district of Chicago, organized under laws of the State of Illinois, for cutting a capacious channel carrying a large discharge from Lake Michigan into the Illinois River for drainage and sanitary purposes. In the reports of the Chief of Engineers, U. S. Army, for the years 1890 and 1891, the reports and estimates of engineers acting under authority of the city of Chicago, and later under the trustees of the sanitary district of Chicago, relating to this matter will be found.

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Further reports and estimates from the engineering department of the sanitary district of Chicago are hereto appended.

No provision has yet been made by Congress for embarking upon the construction of the necessary works to establish navigation over the section from La Salle to Lake Michigan, but the legislature of the State of Illinois has provided for the destruction of the navigation established by locks and dams over the section of the Illinois River from La Salle to Copperas Creek, by requiring the removal of the locks and dams at Henry and Copperas Creek within four years of July 1, 1889, whether or not any other system of navigation be substituted therefor. Under this law these dams must be removed by July 1, 1893.

It must necessarily be many years before any other system of navigation can be substituted for that by locks and dams over this section, and it surely can not be contemplated to carry out the letter of this law. The State has just expended a large sum in rebuilding the gates of the locks, and the utility of the Illinois and Mississippi Canal, the construction of which is just now being undertaken, will be limited to that of a local canal if navigation be not maintained in the Illinois River above Hennepin. The works in question must be maintained until an equally efficient navigation be substituted therefor.

The present project involves the construction of two locks and dams, one at La Grange, 79 miles above the mouth of the Illinois River, the other at Kampsville, 31 miles above its mouth, and dredging the channels to give 7 feet of water at low water over bars. More than 2,000,000 cubic yards of dredging is required.

The depths of navigation under this project, if successfully completed, will vary from 7 feet at extreme low water to 12 feet at mid stage. The depths of water in the Mississippi at low water does not exceed 4½ feet above Cairo; the extreme draft of any steamboat on the Upper Mississippi above St. Louis does not exceed 7 feet, and there is no steamboat on the Mississippi River above New Orleans with a greater depth of hold than 9 feet, or greater safe draft of water than 10.5 feet, which draft is but seldom attained under any conditions. The Illinois River after improvement, if the depths sought be attained, will fulfill all the reasonable requirements of navigation by Western river steamboats.

CONDITION OF THE WORK JUNE 30, 1892.

(a) La Grange Lock.—This lock is completed and in use. The dam is also completed, but there is necessary to preserve it securely against scour some 2,500 cubic yards of riprap to be placed below the apron of the dam. The lock is of 7.4 feet lift, and the dam is 820 feet in length. A small amount of filling should also be placed around the lock superintendent's house and about the grounds to render them more sightly, which work will be gradually done by the regular lock force.

(b) Kampsville Lock and Dam.—The foundations of the lock and dam are completed, and five-sixths of the masonry laid. All the stone has been purchased for the lock. The timber and ironwork for the lock gates and a greater part of the material for the dam has been contracted for.

During the fiscal year ending June 30, 1892, the following work was done:

La Grange Lock and Dam.—A revetment 212 feet in length was built alongshore above the land wall as a guide for boats entering the lock. An ice-breaker was built above the river wall and material collected for constructing guides below the lock, and minor repairs made to lock

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gates, etc. Twelve thousand five hundred cubic yards of material were dredged from the approaches to the lock. The completion of this lock has tripled the tonnage passing this point, even with a less number of boats.

(*a*) *At Kampsville.*—The remainder of the mud overlying the foundation constructed in 18. 3 was removed, i. e., 9,000 cubic yards; making in all 34,114 cubic yards of deposit removed since 1883. Trestles 1,170 linear feet in length for stone travelers for laying the lock walls were constructed. Also trestles for tramway track for delivering stone at the lock walls 1,260 linear feet in length were constructed.

The laying of masonry began September 5, 1891, and was prosecuted until November 30, 1891. A greater part of the time work was prosecuted day and night in laying masonry. Ten thousand one hundred and forty-five cubic yards of masonry were laid in the lock walls, completing course L and lower courses of the lock. The foundation (pile, concrete, and grillage) for the abutment of the dam was constructed and the abutment laid to a height of 10 feet above the foundation. Twenty-seven thousand four hundred and seventy-nine cubic yards of material were dredged above and below the lock pit. One thousand two hundred and fifty-four cubic yards of cut stone were purchased under contract, of which 788 cubic yards have been delivered at the lock site; 6,915 cubic yards of rubble stone for the dam were purchased and delivered.

All of the timber, iron and steel for the lock gates and maneuvering gear of the lock has been contracted for. Also, one-third of the material for the dam, but none of this material has yet been delivered.

The plant has been kept in repair as well as may be, but it is nearly unserviceable as far as floating plant is concerned. The appropriations for this work have been so small and made at such intervals that the plant has decayed, but not worn out, before the work for which it was created, *i. e.*, the dredging and channel work, has been more than begun.

Before the dredging required can be done a complete new dredging outfit must be purchased as far as hulls of floating plant is concerned. The greater part of the machinery is good.

It has been necessary to begin the construction of new dump scows, one of which is practically completed and the other under way. Six barges will also have to be built before the dam can be constructed.

The river during the past spring, and until now, has attained and remains at an unusually high stage, above all stages recorded since 1858. The water still remains above the banks and nearly daily rains give small hope of a speedy decline.

PROPOSED APPLICATION OF FUNDS NOW ON HAND.

The funds on hand will be expended in completing the lock masonry, headbay floor, and lock gates, and purchasing the material for the dam.

PROPOSED APPLICATION OF FUNDS ASKED FOR, FOR FISCAL YEAR ENDING JUNE 30, 1894.

It is proposed to apply the funds asked for herein to the completion of the dam at Kampsville Lock, and to dredging the river between the lock and the Mississippi River, and as far as practicable the pools created by the dams at La Grange and Kampsville.

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It is evident from causes repeatedly mentioned in the reports on this river in the Annual Reports of the Chief of Engineers that the cost of this improvement will exceed the estimate therefor by at least the cost of the dredging plant that must be rebuilt, and by the cost of maintaining and guarding it in enforced idleness for the greater part of thirteen years. The cost of the work proper will not exceed the estimates, but when these estimates were made surely no one could have foreseen that ten years would elapse between the laying the foundation of a lock and the completion of the masonry work, or that nine years would elapse between contracting for the stone and its delivery. The clearing away of the sediment that had accumulated over the foundation of the Kampsville Lock, a material that could not be pumped and that ordinary dredge scows and dipper would not retain, has cost the United States fully half as much as the original lock pit and foundation. In addition to the sedimentary deposit over the lock foundation, fully 100,000 cubic yards of mud have been deposited in the angles above and below the cofferdam at Kampsville, which must be removed before the lock can be thrown open to navigation.

The completion of the La Grange Lock and Dam has been followed by a material increase in the tonnage passing La Grange. The completion of the Kampsville Lock and the dredging the channel below it by extending the period of navigation there will have a more marked effect still in increasing the size and tonnage of vessels navigating the Illinois River and the value of this stream as a means of transportation.

Doubtless the slow improvement of this river has resulted from a difference of opinion as to the method of improvement that should be applied: On the one hand, the necessities of the city of Chicago for better drainage has demanded a large discharge into the Illinois River for sanitary purposes, which discharge would make an open river improvement practicable below Lasalle; on the other hand is the fact that the most economical and effective system, as far as navigation is concerned, is that by slackwater, modified, perhaps, by movable dams in the alluvial valley of the Illinois, Lake Michigan being the summit level, the channels being comparatively shallow but of greater width than proposed for sanitary purposes. Additional friction and consequent injury to both the scheme for a navigable channel and to the local drainage measure, delaying both, has been due to the demand by advocates of the latter that the United States shall construct the navigable channel of the dimensions necessary for the drainage scheme, without regard to the most economical channel and speedy method of meeting the absolute requirements of commerce by water over the connecting link between 14,000 miles of interior navigation existing upon the Mississippi River and its tributaries, and the Great Lakes.

These dissensions are now apparently quieted, and without friction the question of the extension of the navigation existing on the Western rivers to the Great Lakes, the best dimensions and location of channel from Joliet to La Salle, and the advisability and conditions of joint use by the United States for navigation and the city of Chicago for drainage of the channel that must be cut for both purposes across the rock in place, from near Willow Springs to near Lockport, can be now examined.

Upon this subject the reports of the Chief of Engineers for 1889, page 2121 *et seq.*; for 1890, page 2419 *et seq.*; and 1891, page 2611 *et seq.*, are referred to.

The authorities of the sanitary district of Chicago have progressed

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so far with their work as to have definitely located for the third time a part of the drainage channel, and have taken an additional step in advance by soliciting and receiving proposals for the construction of their channel for drainage across the rock between Willow Springs and Lockport. The prices secured are very favorable; the contract has not yet been awarded, but the proposals are under advisement by the trustees.

The report hereto appended of Assistant Engineer C. V. Brainard gives the details of the work accomplished during the past fiscal year:

Money statement.

July 1, 1891, balance unexpended		$159,304.43
June 14, 1892, amount refunded on account of loss of goods		5.50
		159,309.93
June 30, 1892, amount expended during fiscal year		103,999.07
July 1, 1892, balance unexpended		55,310.86
July 1, 1892, outstanding liabilities	$340.45	
July 1, 1892, amount covered by uncompleted contracts	24,715.57	
		25,056.02
July 1, 1892, balance available		30,254.84
Amount appropriated by act approved July 13, 1892		100,000.00
Amount available for fiscal year ending June 30, 1893		130,254.84
Amount (estimated) required for completion of existing project		112,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		112,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

Abstract of proposals for furnishing iron and steel for Kampsville Lock Gates, received and opened at Chicago, Ill., March 30, 1892, by Capt. W. L Marshall, Corps of Engineers.

No.	Name and address of bidders.	Steel (approximate quantities) 40,200 pounds.		Wrought iron (approximate quantities), 40,200 pounds.		Cast iron (approximate quantities), 112,500 pounds.		Grand total.
		Rate per pound.	Total.	Rate per pound.	Total.	Rate per pound.	Total.	
		Cents.		*Cents.*		*Cents.*		
1	Russell Wheel and Foundry Company,* Detroit, Mich	5.95	$2,391.90	5.45	$2,452.50	4.45	$5,006.25	$9,850.65
2	King Bridge Company, Cleveland, Ohio	15.00	6,030.00	10.00	4,500.00	6	6,750.00	17,280.00
3	H. A. Ainsworth, Moline, Ill	5.85	2,351.70	4.95	2,227.50	4.95	5,568.75	10,147.95
4	Vulcan Iron Works, Chicago, Ill	6.067	2,438.93	8.913	4,010.85	5.589	6,287.62	12,737.40
5	Excelsior Iron Works, Chicago, Ill	5.95	2,391.90	6.99	3,145.50	4.88½	5,495.62	11,032.02

* Lowest bidder.

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Illinois River improvement.—Abstract of proposals for furnishing timber for Kampsville Lock and Dam, Illinois River, received and opened at Chicago, Illinois, Tuesday, May 10, 1892, by Capt. W. L. Marshall, Corps of Engineers.

No.	Name and address of bidders.	Quantities.							
		Selected white-oak timber and plank, 47,121 feet, B. M.		Selected cypress matched plank 11,982 feet, B. M.		White-oak timber Headbay and Dam, 84,164 feet, B. M.		White-oak plank Headbay and Dam, 482,772 feet, B. M.	
		Price per M feet.	Total.	Price per M feet.	Total.	Price per M feet.	Total.	Price per M feet.	Total.
1	C. Crane & Co., Cincinnati, Ohio *	$45.00	$2,120.45	.....	.....	$30.00	$2,524.92	$30.00	$14,483.16
2	Franklin Duff (Duff & Co.), St. Louis, Mo.*	45.00	2,120.45	.....	.....	29.50	2,482.84	31.50	15,207.32
3	The A. R. Beck Lumber Company, South Chicago, Ill.*	.....	.....	.....	.....	.....	.....	.....	.....
4	Wm. Towle & Co., Metropolis, Ill.*	50.00	2,356.05	40.00	479.28	40.00	3,366.56	.....	.....
5	The Little Rock Lumber Company, Council Bluffs, Iowa ‡	50.00	2,356.05	.....	.....	35.00	2,945.74	35.00	16,897.02
6	H. B. Wyeth (Southern Lumber Company), St. Louis, Mo.*	51.74	2,438.04	.....	.....	30.10	2,533.34	27.40	13,227.95
7	W. A. Bonsack, St. Louis, Mo.*	52.00	2,450.29	50.00	599.10	34.00	2,861.58	34.00	16,414.25

No.	Name and address of bidders.	Quantities.					Combined total bid on—		
		Pine lumber, Headbay and Dam, 44,096 feet, B. M.		Pine plank, Headbay and Dam, 22,890 feet, B. M.		Total of bid 693,025 feet, B. M.	White oak timber and plank.	Cypress timber.	Pine lumber and plank.
		Price per M feet.	Total.	Price per M feet.	Total.				
1	C. Crane & Co., Cincinnati, Ohio *	.....	.....	.....	.....	$19,128.53	$19,128.53	.....	.....
2	Franklin Duff (Duff & Co.), St. Louis, Mo.*	$24.50	$1,080.35	$23.00	$526.47	21,417.43	19,810.61	.....	$1,606.82
3	The A. R. Beck Lumber Company, South Chicago, Ill.*	18.70	824.60	16.95	387.99	1,212.59	.....	.....	† 1,212.59
4	Wm. Towle & Co., Metropolis, Ill.*	.....	.....	.....	.....	6,201.89	.....	†$479.28	.....
5	The Little Rock Lumber Company, Council Bluffs, Iowa ‡	.....	.....	.....	.....	22,198.81	22,198.81	.....	.....
6	H. B. Wyeth (Southern Lumber Company), St. Louis, Mo.*	19.00	837.82	19.00	434.91	19,472.06	†18,199.33	.....	1,272.73
7	W. A. Bonsack, St. Louis, Mo.*	30.00	1,322.88	30.00	686.70	24,334.80	21,726.12	599.10	2,009.58

* Delivery to be made at Columbiana, Ill.
† Lowest bidders.
‡ Delivery to be made at Kampsville, Ill.
NOTE.—H. B. Wyeth's bid is for yellow pine.

Contract for white oak timber and plank awarded to H. B. Wyeth, Southern Lumber Company, St. Louis, Mo.

Contract for cypress plank awarded to William Towle & Co., Metropolis, Ill.

Contract for pine lumber and plank awarded to The A. R. Beck Lumber Company, South Chicago, Ill.

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Abstract of contracts for constructing Kampsville Lock and Dam, Illinois River, in force during the fiscal year ending June 30, 1892.

Name and address of contractors.	Nature of contract.	Date.	To expire.
Sanger & Moody, Joliet, Ill	Furnishing and delivering at lock site 1,254 cubic yards of stone.	Feb. 10, 1891	*Nov. 30, 1891
The Russel Wheel and Foundry Co., Detroit, Mich.	Furnishing 197,700 pounds iron and steel fittings for lock gates.	Apr. 11, 1892	Aug. 1, 1892
H. B. Wyeth, St. Louis, Mo.....	Furnishing 246,722 feet, B. M., lumber.	May 31, 1892	Sept. 1, 1892
The A. R. Beck Lumber Co., South Chicago, Ill.	Furnishing 66,986 feet, B. M., lumber ..	June 15, 1892	42 days subsequent to notification.

* Contract extended to August 31, 1892.

REPORT OF MR. C. V. BRAINARD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Kampsville, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit the following report of operations for improving Illinois River for the year ending June 30, 1892.

Kampsville Lock.—At the beginning of the fiscal year about 9,000 cubic yards of mud remained to be cleared off the foundation. After removing 1,350 cubic yards with dredges, the gap in the side of the cofferdam was closed and the water pumped out. The mud remaining on the wall sites was then removed. A part of this was removed by pumping it over the cofferdam. The most of it, however, was wheeled to derricks, dumped into scale boxes, and hoisted outside. About 1,650 cubic yards were removed in this way. After the walls were partially up about 3,000 cubic yards, which had been left in the center of the foundation, was wheeled back of the land wall. There was altogether about 34,000 cubic yards of dirt removed from the lock pit.

Two hundred and fifty-four piles and 54 sheet piles were driven. Sixteen piles and 54 sheet piles in closing the opening in the cofferdam, 228 piles for the traveler and railroad trestles, and 6 piles for a derrick support. There was built 1,170 linear feet of traveler trestle for laying the lock walls and 1,260 linear feet of railroad trestle for delivering stone at the walls.

In the traveler trestle at the stone pile 16 of the old elm piles were replaced by 10 by 10 inch pine timbers.

Two thousand feet of railroad track with the necessary switches were laid from the stone pile to the walls for the delivery of stone at the work.

One thousand six hundred and twenty-six square yards of the foundation were leveled with a layer of concrete varying from 0.1 foot to 0.25 foot in thickness.

The work of laying the walls was begun September 5, 1891, and continued until November 30, when the "L" course, making the walls 20 feet and 3 inches high, was completed, including both miter sills and the breast wall, except the coping of the upper miter sill. From September 29 until November 18 the work was carried on continuously day and night. Night work on the walls was stopped at this time on account of the freezing weather at night. During this time, 4,610 cubic yards of face and 5,535 cubic yards of backing stone were set.

About 900 cubic yards of broken stone were used for concrete in filling the joints of the backing.

In laying the walls three overhead travelers were used, one over each wall and one at the pile of cut stone. Two derricks with a steam hoist handled the backing in the stone yard. A railroad track about 10 feet above the foundation runs along the outside of each wall for its entire length, the stone being brought down on cars and stopped opposite where it belongs in the wall. It was unloaded by the traveler and placed on the wall to be used when needed.

The night work was carried on by the aid of nine Wells lights of 1,200 candle power each. During the time these lights burned they averaged 2 barrels of coal oil each night.

One hundred and ninety-one pieces of quarry stone for the river wall were recut to a pitch line, giving them a batter of 3 inches to the foot. Twenty-four pieces of coping were recut. This recutting was made necessary by a change in the plans of the river wall after a part of the stone had been delivered. The lower miter sill timbers were framed and bolted into position.

December 4, 1891, dredging above and below the lock was begun and continued until April 2, 1892, since which time no dredging has been done because of high water. From December 4 to 20 work was carried on day and night. From the 20th to the

30th no work was done on account of sickness among the dredge crew. From January 7 to February 5 the river was closed with ice and no dredging was done. The channel below the lock was dredged to a depth of 7 feet below low water. Twenty-four thousand and nine cubic yards of material were scowed from the channel to the east side of the river below the site for the dam. Three thousand four hundred and seventy cubic yards were scowed away from above the lock to furnish a landing for loading and unloading boats.

Dredge No. 1 having been at La Grange Lock during the winter was brought to this point April 2 and put in condition for work, but on account of high water has done no dredging yet.

A levee 195 feet long and 13 feet above low water was built across the upper end of the cofferdam to protect the trestles from the ice.

In addition to the 3,000 cubic yards of dirt from the lock floor put back of the land wall, 1,380 cubic yards were filled in with wagons and wheelbarrows, making a total of 4,380 cubic yards filled back of the land wall during the year. Four low-water discharges were measured and reduced.

The following material was received: 1,100 tons of coal; for lock walls, 4,719 barrels of cement, 775.8 cubic yards of sand, 786.16 cubic yards of face stone, 6,915 cubic yards of rubble, of which 6,515 cubic yards were for the dam; 9,284 feet, B. M., of lumber for repairs to trestles; for two new dump scows, 23,027 feet, B. M., of oak lumber, 23,152 feet, B. M., of pine lumber, 8 tamarack knees, 2,806 pounds of machine bolts, 873 pounds of drift bolts, 2,850 pounds of wrought spikes, 32 pounds of nuts, 200 pounds of washers, 2,808 pounds of flat iron, 734 pounds of round iron, 2,208 pounds of chain, 32 turnbuckles and 8 iron sheaves.

Kampsville Dam.—Six hundred and seventy cubic yards of material were excavated from the site of the east abutment; the foundation, consisting of 81 piles with a grillage on top filled in with 32 cubic yards of concrete 20 inches deep, was put in. One hundred and ninety-six cubic yards of stone was set in the abutment, making it 10 feet above low water. There remains 7 feet in height to be built yet.

PLANT.

Dredge No. 1.—Two new eyebolts for truss were made. The packing rings were taken out of the cylinders, cleaned and replaced; four new spring bolts and four new stud bolts were made for the pistons. One new tube was put in the boiler, and the rest rolled. A new leather valve was put in each of the front spud hoist cylinders.

Dredge No. 2.—The following repairs were made: Two spud hoist stirrups repaired, two new saddle-block bolts made, a patch put on each boiler, seventeen new tubes put in boilers, new rubbing planks put on crane, a new timber head, a new dipper latch, the 2¼-yard dipper was replaced by a 1½-yard dipper, the friction blocks of the hoisting drum were set out one-half inch.

Steamer Hebe.—A new smoke stack was put on; a Worthington 6 inch by 10 inch by 6 inch steam pump, to be used for washing scows, was put on; twenty-seven leaking tubes were taken out and replaced by others with copper ferrules; two new tubes were put in the heater; a new stock was made for the rudder.

Steamer Enterprise.—Two new wheel buckets were made and put on the wheels. A new cylinder head was furnished one of the cylinders. Both boilers were patched over the fire. Twenty-four new tubes were put in the boilers. During the winter the capstan engines, which had always given a great amount of trouble, were taken out of the hold, the lost motion taken out and lined up and replaced in the hold. The main engines were overhauled, and the shafts lined up.

Travelers.—The land-wall traveler was furnished with two new truck wheels and a new hoisting cable. A new bridge was built for this one, increasing the span from 24 feet to 30 feet. The river-wall traveler was furnished with two new flanges for truck wheels, new hoisting cable, and two new leathers on the friction cone. The stone-yard traveler was furnished with three new flanges for truck wheels, new hoisting cable, a new rocker arm, and new leathers for friction cone.

Pumping machinery.—One of the 6-inch centrifugal pumps was furnished with a new bottom half and a new piston. One of the boilers was patched and three new tubes put in. A Blake pump, No. 6, furnished with the necessary steam and water connections, was set up at the pump house to furnish water to the boarding house, for mixing mortar on the walls, and to the two travelers.

Barges and scows.—The old dump scows needed continual repairs during dredging operations, the labor for them costing not less than 1 cent per yard for all the material dredged. Material has been received for two new scows, which would have been completed in May but for the high water stopping work on them, one being completed, except hanging the doors and the dumping arrangements. The other has the framework nearly completed.

The ice boat has been hauled out twice and the seams made in. One hundred square feet of new bottom, one new rake plank, and new fender strakes were put on. The 15 by 75 foot barge was calked to light water and the hull cleaned out. Eighteen

square feet of graven pieces were put in and 35 square feet of new deck laid. The 18 by 50 foot barge was on the bank and had what calking was necessary done and forty-eight oak stanchions put in the hold.

Office boat.—The hull was cleaned out and the leaks were stopped. New outriggers and new nosing were put on around the boat. The roof, except the skylight, was covered with canvas.

Skiffs.—These were kept repaired and painted.

Stone cars.—Eight stone cars were built. One of them having run off the end of the trestle was rebuilt.

Shop.—The end porches were closed, giving a shop 15 by 72 feet. The machinery was set up and one of the New Era boilers placed in the shop to furnish steam. A new canvas roof was put on.

Derricks.—One new mast was made. Three new spider frames were made for the boom sheaves and nine new pins for shackle connections.

Tools.—Those in general use have been kept in repair.

Since April 21 work has been entirely suspended, except taking care of property, on account of high water. The water is still over the bank and rising.

During the year three men lost their lives on this work. On November 28, Assistant Engineer W. M. Childs, in charge of this work, was struck on the head with a falling derrick boom and died two and one-half hours later. On November 11, James P. Waller, a mason, was struck with a falling derrick boom and his leg crushed. He died November 24. On June 18, Jan Sam, a laborer, fell overboard and was drowned.

Very respectfully, your obedient servant,

C. V. BRAINARD,
Assistant Engineer.

Discharge of Illinois River at Kampsville, Ill., October 18, 1891.

Station.	Soundings in feet.	Partial areas.	No. of registrations. For 120 seconds.	No. of registrations. Per second.	Mid-depth velocities.	Mean velocities.	Partial discharges.	Remarks.
+3	0.0 West edge.							
	2.5							
15 1	3.0	101.25	17	.142	.635	.620	62.8	Gauge.—7 a. m., 0.15; noon, 0.15; 6 p. m., 0.15. Strong wind down stream. Time, 10 to 11 a. m. C. V. Brainard, observer.
	3.0							
2	3.2	92.25	25	.208	.940	.934	86.2	
	2.9							
3	3.3	96.75	26	.217	.982	.978	94.6	
	3.4							
4	3.1	96.00	21	.175	.787	.776	74.5	
	3.2							
5	3.2	96.00	25	.208	.940	.934	89.7	
	3.2							
6	3.1	93.00	26	.217	.982	.976	90.8	
	3.0							
7	2.8	85.50	20	.167	.750	.937	80.1	
	2.8							
8	2.6	78.00	20	.167	.750	.936	73.0	
	2.4							
9	2.2	66.00	23	.192	.866	.953	62.9	
	2.0							
10	2.5	81.00	17	.142	.635	.618	50.1	
	3.8							
11	4.4	135.00	17	.142	.635	.624	84.2	
	5.4							
12	6.6	205.50	19	.158	.708	.703	144.5	
	8.8							
13	10.2	294.00	21	.175	.787	.789	232.0	
	10.0							
14	10.2	285.00	24	.200	.903	.910	259.3	
	7.6							
15	6.1	188.25	24	.200	.903	.904	170.2	
	5.3							
16	4.8	141.75	23	.192	.866	.863	122.3	
	4.0							
17	4.3	123.75	17	.142	.635	.624	77.2	
	3.9							
18	2.4	61.65	11	.092	.403	.382	23.6	
552	0.0 East edge.							

Total area of cross section ..... square feet.. 2320.65
Total discharge ..... cubic feet per second.. 1878.0
Mean velocity ..... feet per second.. 0.809

Discharge of Illinois River at Kampsville, Ill., October 18, 1891.

Station.	Soundings in feet.	Partial areas.	No. of registrations. For 120 seconds.	No. of registrations. Per second.	Mid-depth velocities.	Mean velocities.	Partial discharges.	Remarks.
+3	2.5 0.0 West edge.							
15 1	2.9	99.75	14	.117	0.519	5.02	50.1	Gauge. — . a. m., —0.15; noon,—0.15; 6 p. m.. 0.15. Time, 11 a. m. to 12.20 p. m. Strong wind downstream. C. V. Brainard, observer.
2	3.0 3.2	93.00	27	.225	1.018	1.015	94.4	
3	3.0 3.2	91.50	29	.242	1.097	1.096	100.3	
4	3.2 3.2	96.00	25	.208	.940	.934	89.7	
5	3.2 3.8	96.75	25	.208	.940	.934	90.4	
6	3.0 3.1	93.00	21	.175	.787	.775	72.1	
7	2.8 2.8	86.25	26	.217	.982	.973	83.9	
8	2.6 2.5	78.75	27	.225	1.018	1.012	79.7	
9	2.4 2.0	69.75	27	.225	1.018	1.011	70.5	
10	2.6 3.7	81.75	19	.158	.708	.692	56.6	
11	4.4 5.2	132.75	17	.142	.635	.618	82.0	
12	6.8 8.8	207.00	19	.158	.708	.702	145.3	
13	10.2 10.0	294.00	19	.158	.708	.708	208.2	
14	10.2 8.0	288.00	22	.183	.824	.828	238.5	
15	6.2 5.4	193.50	26	.217	.982	.985	190.6	
16	4.8 4.1	143.25	23	.192	.866	.863	123.6	
17	4.4 4.0	126.75	17	.142	.635	.625	79.2	
18	2.2	59.70	11	.092	.403	.382	22.8	
552	0.0 East edge.							

NOTE.—For method of reducing mid-depth velocities to mean velocities, see page 56, professional papers of the Corps of Engineers, U. S. A., No. 12. Soundings are taken every 15 feet.

Total area of cross section.....square feet.. 2,331.45
Total discharge .....cubic feet per second.. 1,877.9
Mean velocity .....feet per second.. .0805

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Discharge of Illinois River at Kampsville, Ill., October 20, 1891.

Station.	Soundings in feet.	Partial areas.	No. of registrations. For 300 seconds. Seconds.	Registrations.	Per second.	Mid-depth velocities.	Mean velocities.	Partial discharges.	Remarks.
15 0+4	0.0 Shore.								
	2.3								
1	2.9	94.40	158	12	.076	.329	.309	29.2	Gauge.—7 a. m., —0.25; noon,—0.25; 6 p. m.,—0.25. Time, a. m. From west to east. Brisk breeze upstream. W. M. Childs, observer.
	2.8								
2	3.1	88.50	99	19	.192	.866	.857	75.8	
	2.8								
3	3.1	91.50	125	24	.192	.866	.857	78.4	
	3.2								
4	3.0	92.25	110	20	.182	.820	.810	74.7	
	3.1								
5	3.1	94.50	109	18	.165	.741	.729	68.9	
	3.3								
6	3.1	93.00	122	18	.148	.662	.647	60.2	
	2.9								
7	2.6	79.50	138	20	.145	.649	.635	50.5	
	2.5								
8	2.3	69.75	126	15	.119	.528	.508	35.4	
	2.2								
9	2.1	63.00	117	16	.137	.612	.592	37.3	
	2.0								
10	2.2	73.50	136	13	.096	.422	.401	29.5	
	3.4								
11	4.2	128.25	116	10	.086	.376	.359	46.0	
	5.3								
12	6.9	199.50	122	15	.123	.547	.539	107.5	
	7.5								
13	9.7	276.75	140	22	.157	.704	.704	194.8	
	10.0								
14	10.1	285.75	108	19	.176	.792	.795	227.2	
	7.9								
15	6.0	189.00	131	26	.199	.898	.899	169.9	
	5.3								
16	4.6	138.75	125	21	.168	.755	.747	103.6	
	4.0								
17	4.2	118.50	121	15	.124	.552	.538	63.8	
	3.4								
18	1.8	47.10	120	.....	.....	.....	.....	.....	
349	0.0 Shore.								

Total area of cross section.....square feet.. 2,223.5
Total discharge .....cubic feet per second.. 1,452.7
Mean velocity.....feet per second.. 0.653

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Discharge of Illinois River at Kampsville, Ill., October 20, 1891.

Station.	Soundings in feet.	Partial areas.	No. of registrations. For 300 seconds. Seconds.	Registrations.	Per second.	Mid-depth velocities.	Mean velocities.	Partial discharges.	Remarks.
0+3	0.0 Shore.								
	2.3								
15 1	2.9	95.55	117	11	.094	.413	.394	37.6	Gauge.—7 a. m., −0.25; noon, −0.25; 6 p. m., −0.25. Time, p. m. From west to east. Brisk breeze upstream. J. R. Fuller, observer.
	2.8								
2	3.1	88.50	114	21	.184	.828	.818	72.4	
	2.8								
3	3.1	91.50	120	24	.200	.903	.895	81.9	
	3.2								
4	3.0	92.25	121	21	.174	.783	.771	71.1	
	3.1								
5	3.1	94.50	122	21	.172	.773	.761	71.9	
	3.3								
6	3.1	93.75	124	19	.153	.686	.672	63.0	
	3.0								
7	2.6	81.75	120	18	.150	.672	.655	53.5	
	2.7								
8	2.4	73.50	126	16	.127	.565	.547	40.2	
	2.3								
9	2.2	64.50	122	15	.123	.547	.528	34.1	
	1.9								
10	2.2	72.75	128	11	.086	.376	.355	25.8	
	3.4								
11	4.4	131.25	134	13	.097	.427	.412	54.1	
	5.3								
12	6.7	196.50	121	15	.124	.552	.543	106.7	
	7.5								
13	9.7	276.00	132	21	.159	.713	.713	196.8	
	9.9								
14	10.1	286.50	118	23	.195	.880	.886	253.8	
	8.1								
15	6.1	192.75	121	22	.182	.820	.818	157.7	
	5.4								
16	4.7	141.00	124	19	.153	.686	.675	95.2	
	4.0								
17	4.2	121.50	122	15	.123	.547	.533	64.8	
	3.8								
18	1.8	51.00	121	2	.017	.057	.047	24.0	
550	0.0 Shore.								

Total area of cross section.....square feet.. 2,245.05
Total discharge .....cubic feet per second.. 1,504.6
Mean velocity.....feet per second.. 0.67

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Readings of the upper gauge at Copperas Creek Lock, 1891.

[Plane of reference: Top of lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	12.18	11.80	13.78	14.88	17.70	12.20	13.40	11.70	11.60	11.50	11.40	12.10
2	12.20	11.80	13.85	15.02	17.55	12.15	13.22	11.75	11.60	11.50	11.40	12.10
3	12.25	11.85	13.93	15.20	17.35	12.25	12.97	11.75	11.60	11.50	11.40	13.10
4	12.30	11.95	13.95	15.83	17.10	12.30	12.80	11.75	11.60	11.45	11.40	12.10
5	12.30	11.98	13.88	15.45	17.02	12.27	12.75	11.70	11.60	11.40	11.40	12.10
6	12.30	12.00	13.78	15.55	16.85	12.25	12.60	11.70	11.60	11.40	11.40	12.30
7	12.30	12.00	13.72	15.72	16.60	12.37	12.50	11.70	11.60	11.40	11.40	12.40
8	12.30	12.00	13.70	15.80	16.23	12.37	12.55	11.70	11.60	11.40	11.60	12.40
9	12.30	12.00	13.67	15.83	16.07	12.55	12.45	11.70	11.55	11.40	11.60	12.40
10	12.30	12.00	13.40	16.07	15.87	12.65	12.45	11.70	11.50	11.40	11.60	12.40
11	12.30	12.00	13.40	16.10	15.68	12.80	12.35	11.70	11.45	11.40	11.60	12.40
12	12.22	12.00	15.40	16.57	15.53	12.85	12.30	11.70	11.45	11.40	11.60	12.40
13	12.20	12.00	13.40	16.93	15.33	12.90	12.20	11.70	11.50	11.40	11.60	12.40
14	12.15	12.00	13.33	17.17	15.12	12.90	12.17	11.78	11.50	11.40	11.60	12.45
15	12.10	12.00	13.35	17.53	14.87	13.00	12.02	12.00	11.50	11.40	11.60	12.45
16	12.05	12.00	13.35	17.75	14.68	13.00	12.00	11.70	11.50	11.40	11.60	12.50
17	12.05	12.00	13.35	18.05	14.37	13.07	11.97	11.70	11.50	11.40	11.60	15.50
18	12.05	11.95	13.48	18.25	14.07	13.53	12.00	11.70	11.50	11.25	11.60	12.50
19	12.00	12.00	13.62	18.45	13.83	13.55	12.00	11.70	11.50	11.20	11.60	12.50
20	12.00	12.32	13.73	18.57	13.68	13.70	12.00	11.70	11.50	11.15	11.67	12.50
21	12.00	12.40	13.77	18.70	13.45	13.72	12.00	11.70	11.50	11.15	11.72	12.50
22	11.90	12.57	13.80	18.73	13.42	13.80	12.00	11.60	11.50	11.20	11.80	12.53
23	11.90	12.68	13.80	18.80	13.20	13.90	12.00	11.60	11.55	11.20	11.85	12.50
24	11.90	12.85	13.92	18.77	13.10	13.95	11.90	11.60	11.60	11.30	11.95	12.55
25	11.85	13.20	14.02	18.73	13.00	14.00	11.90	11.60	11.65	11.30	12.00	12.55
26	11.85	13.43	14.07	18.57	12.70	13.80	11.90	11.60	11.65	11.30	12.05	12.55
27	11.85	13.62	14.37	18.50	12.50	13.75	11.85	11.60	11.60	11.35	12.05	12.55
28	11.85	13.75	14.45	18.37	12.50	13.70	11.80	11.60	11.60	11.35	12.05	12.60
29	11.80	.....	14.52	18.17	12.45	13.60	11.75	11.60	11.60	11.40	12.05	12.60
30	11.80	.....	14.70	17.92	12.37	13.50	11.70	11.60	11.50	11.40	12.08	12.60
31	11.80	.....	14.75	.....	12.23	.....	11.70	11.60	.....	11.40	.....	12.60
Means	12.07	12.29	13.81	17.18	14.72	13.07	12.23	11.68	11.55	11.36	11.68	12.42

Readings of the lower gauge at Copperas Creek Lock, 1891.

[Plane of reference: Top of lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	8.65	8.00	12.72	14.53	17.58	10.25	12.53	7.50	7.78	7.08	6.95	8.65
2	8.70	8.00	12.85	14.67	17.40	10.10	12.25	7.58	7.70	7.00	6.95	8.65
3	8.80	8.10	12.98	14.82	17.23	10.73	11.93	7.62	7.73	7.00	6.95	8.70
4	8.87	8.20	13.05	15.00	17.03	10.95	11.75	7.65	7.70	7.00	6.95	8.80
5	8.93	8.33	13.05	15.10	17.00	10.75	11.60	7.55	7.70	7.00	6.95	8.90
6	9.00	8.40	13.00	15.22	16.97	10.30	11.50	7.55	7.70	7.00	6.95	8.95
7	9.10	8.40	12.87	15.38	16.60	15.30	11.20	7.55	7.65	7.00	6.95	9.00
8	9.17	8.38	12.80	15.40	16.13	10.42	11.23	7.55	7.57	7.00	6.98	9.10
9	9.20	8.35	12.80	15.45	15.73	10.60	11.00	7.53	7.55	7.00	7.00	9.10
10	9.20	8.30	12.60	15.75	15.40	10.77	10.87	7.52	7.50	7.00	7.00	9.10
11	9.20	8.28	12.50	15.80	15.10	11.00	10.47	7.55	7.40	7.00	7.00	9.10
12	9.17	8.20	12.40	16.23	14.83	11.15	10.38	7.55	7.40	7.00	7.05	9.10
13	9.10	8.13	12.40	16.55	14.70	11.42	10.18	7.60	7.40	6.97	7.08	9.10
14	9.07	8.10	12.40	16.93	14.40	11.50	10.08	7.93	7.40	6.95	7.13	9.17
15	9.00	8.10	12.40	17.33	14.30	11.73	9.67	8.60	7.40	6.88	7.20	9.15
16	8.83	8.10	12.40	17.60	14.20	11.85	9.37	9.00	7.37	6.77	7.20	9.15
17	8.80	8.10	12.40	17.90	13.93	11.85	9.25	9.50	7.30	6.80	7.18	9.27
18	8.75	8.10	12.62	18.17	13.78	12.83	9.25	9.50	7.30	6.80	7.15	9.40
19	8.65	8.13	12.75	18.35	13.48	12.80	9.18	9.40	7.30	6.80	7.17	9.40
20	8.60	8.73	13.03	18.42	13.28	12.90	9.03	9.30	7.27	6.80	7.35	9.40
21	8.47	9.47	13.02	18.50	13.15	12.98	8.90	9.17	7.25	6.85	7.77	9.40
22	8.40	10.13	13.00	18.55	13.00	13.20	8.73	9.00	7.25	6.90	8.00	9.45
23	8.32	10.70	13.00	18.60	12.80	13.30	8.47	8.77	7.25	6.90	8.05	9.50
24	8.22	11.02	13.12	18.55	12.73	13.33	8.20	8.57	7.25	6.90	8.20	9.60
25	8.20	11.58	13.35	18.50	12.52	13.33	8.00	8.25	7.25	6.90	8.35	9.60
26	8.18	11.93	13.42	18.40	12.22	13.20	8.00	7.92	7.25	6.90	8.50	9.60
27	8.10	12.28	13.75	18.35	11.80	13.15	7.93	7.72	7.20	6.95	8.50	9.60
28	8.05	12.63	13.87	18.22	11.47	13.10	7.80	7.80	7.20	6.95	8.50	9.60
29	8.00	.....	13.97	18.03	11.12	12.95	7.75	7.80	7.15	6.95	8.50	9.60
30	8.00	.....	14.10	17.78	10.73	12.72	7.65	7.80	7.13	6.95	8.63	9.60
31	8.00	.....	14.28	.....	10.47	.....	7.50	7.80	.....	6.95	.....	9.60
Means	8.67	9.08	13.00	16.94	14.23	11.85	9.73	8.13	7.41	6.93	7.47	9.24

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Readings of the upper gauge at La Grange Lock, 1891.

[Plane of reference: Top of lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	15.35	15.50	16.67	17.35	19.93	16.30	16.75	15.30	15.45	15.20	15.20	15.83
2	15.52	15.50	16.73	17.35	19.80	16.20	16.70	15.30	15.42	15.20	15.22	15.77
3	15.75	15.53	16.70	17.38	19.70	16.22	16.65	15.37	15.45	15.15	15.25	15.82
4	15.85	15.47	16.50	17.45	19.53	16.47	16.67	15.43	15.47	15.20	15.23	15.83
5	15.85	15.43	16.63	17.47	19.35	16.53	16.53	15.35	15.37	15.17	15.20	15.92
6	15.80	15.50	16.65	17.52	19.15	16.42	16.38	15.27	15.40	15.20	15.25	16.03
7	15.75	15.47	16.77	17.58	18.90	16.48	16.37	15.28	15.30	15.27	15.23	16.07
8	15.70	15.50	16.80	17.62	18.70	16.37	16.33	15.23	15.37	15.23	15.30	16.08
9	15.67	15.45	16.82	17.73	18.45	16.38	16.32	15.20	15.37	15.23	15.42	16.10
10	15.65	15.42	16.80	17.77	18.33	16.40	16.30	15.22	15.37	15.22	15.33	16.12
11	15.80	15.45	16.83	17.83	18.22	16.33	16.23	15.67	15.27	15.23	15.30	16.20
12	15.75	15.60	16.90	17.80	18.05	16.40	16.13	15.45	15.30	15.20	15.25	16.23
13	15.75	15.60	16.87	17.92	17.87	16.40	16.05	15.35	15.27	15.22	15.30	16.25
14	15.62	15.57	16.80	18.03	17.78	16.40	16.15	15.45	15.27	15.13	15.35	16.25
15	15.60	15.56	16.77	18.18	17.67	16.42	16.15	15.50	15.27	15.15	15.40	16.25
16	15.55	15.52	16.80	18.27	17.60	16.40	15.97	15.95	15.32	15.20	15.47	16.30
17	15.57	15.53	16.80	18.50	17.53	16.55	15.83	16.55	15.32	15.07	15.50	16.35
18	15.55	15.52	16.87	18.80	17.42	16.57	15.80	16.47	15.27	15.13	15.55	16.35
19	15.60	15.57	16.92	19.05	17.05	16.65	15.75	16.20	15.30	15.15	15.50	16.33
20	15.60	15.85	16.95	19.27	17.17	16.68	15.70	16.13	15.30	15.20	15.55	16.35
21	15.60	16.20	16.97	19.55	17.82	16.73	15.73	16.00	15.27	15.22	15.65	16.32
22	15.57	16.50	16.95	19.90	17.72	16.82	15.63	15.87	15.30	15.20	15.90	16.28
23	15.52	16.45	16.97	20.13	17.32	16.85	15.57	15.70	15.27	15.20	16.12	16.37
24	15.50	16.47	17.00	20.20	17.17	16.85	15.50	15.63	15.32	15.23	16.08	16.38
25	15.55	16.55	17.00	20.23	17.05	16.85	15.47	15.55	15.27	15.17	16.00	16.30
26	15.50	16.55	17.00	20.25	16.85	16.87	15.40	15.50	15.27	15.10	15.95	16.28
27	15.50	16.60	17.05	20.25	16.75	16.85	15.30	15.47	15.27	15.22	15.93	16.32
28	15.50	16.67	17.18	20.13	16.67	16.85	15.43	15.43	15.20	15.23	15.92	16.30
29	15.48	.....	17.17	20.05	16.63	16.85	15.40	15.40	15.22	15.15	15.93	16.30
30	15.47	.....	17.28	20.00	16.47	16.80	15.42	15.37	15.20	15.12	15.87	16.30
31	15.50	.....	17.35		16.35	.....	15.35	15.38	.....	15.10	.....	16.30
Means	15.61	15.80	16.88	18.65	17.90	16.56	15.97	15.58	15.31	15.19	15.54	16.19

Reading of the lower gauge at La Grange Lock 1891.

[Plate of reference: Top of lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	8.55	8.87	12.37	14.27	19.50	11.63	12.90	8.50	8.50	7.52	7.20	9.03
2	8.95	8.83	12.48	14.35	19.40	11.30	12.75	8.83	8.42	7.40	7.22	8.82
3	9.45	8.77	12.45	14.45	19.27	11.27	12.63	9.07	8.47	7.35	7.28	8.93
4	9.75	8.70	12.30	14.63	19.05	11.82	12.45	8.85	8.45	7.40	7.35	8.93
5	9.90	8.75	12.33	14.73	18.83	12.10	12.32	8.70	8.35	7.40	7.35	9.25
6	9.75	8.63	12.35	14.85	18.60	11.98	11.95	8.40	8.30	7.42	7.40	9.50
7	9.60	8.73	12.65	14.97	18.35	11.87	11.80	8.27	8.37	7.55	7.42	9.55
8	9.50	8.82	12.72	15.10	18.07	11.78	11.70	8.20	8.25	7.47	7.45	9.57
9	9.45	8.80	12.77	15.43	17.82	11.77	11.57	8.13	8.07	7.50	7.72	9.63
10	9.57	8.77	12.78	15.75	17.53	11.83	11.58	8.38	8.00	7.43	7.83	9.82
11	9.58	8.83	12.87	15.90	17.25	11.72	11.40	9.00	7.97	7.42	7.72	9.80
12	9.55	8.90	12.98	16.03	16.93	11.65	11.33	9.20	7.87	7.40	7.63	9.88
13	9.47	8.90	12.95	16.15	16.60	11.57	11.02	8.67	7.90	7.33	7.62	9.92
14	9.40	8.87	12.92	16.32	16.27	11.63	10.72	8.68	7.83	7.20	7.73	9.95
15	9.40	8.85	12.83	16.47	15.97	11.62	10.80	8.87	7.80	7.12	7.87	9.97
16	9.33	8.83	12.85	16.78	15.68	11.65	10.67	9.95	7.85	7.20	7.98	10.05
17	9.23	8.80	12.85	17.30	15.32	11.75	10.27	11.45	7.77	7.13	8.15	10.10
18	9.15	8.80	13.00	17.95	15.03	11.77	10.03	11.42	7.75	7.12	8.20	10.10
19	9.15	8.87	13.17	18.27	14.75	12.03	9.95	10.90	7.82	7.25	8.25	10.10
20	9.15	9.63	13.28	18.58	14.47	12.40	9.77	10.50	7.75	7.25	8.35	10.20
21	9.12	10.50	13.33	18.80	15.83	12.65	9.63	10.15	7.72	7.32	8.52	10.17
22	8.93	11.67	13.30	19.27	15.75	12.90	9.47	9.80	7.65	7.30	9.30	10.18
23	8.92	11.70	13.32	19.58	15.15	13.03	9.33	9.45	7.62	7.30	9.70	10.27
24	8.93	11.78	13.35	19.53	14.53	13.05	9.17	9.17	7.65	7.35	9.65	10.28
25	8.87	11.80	13.43	19.77	14.00	13.05	9.07	8.95	7.65	7.25	9.53	10.25
26	8.85	11.85	13.55	19.80	13.60	13.12	8.93	8.78	7.63	7.35	9.37	10.12
27	8.85	12.05	13.60	19.80	13.20	13.15	8.72	8.85	7.62	7.37	9.35	10.13
28	8.80	12.33	13.75	19.73	12.77	13.10	9.05	8.83	7.55	7.33	9.32	10.10
29	8.80	.....	13.90	19.70	12.48	13.10	9.10	8.77	7.47	7.27	9.23	10.07
30	8.80	.....	14.10	19.65	12.15	13.00	8.85	8.67	7.53	7.18	9.07	10.05
31	8.87	.....	14.25		11.87	.....	8.65	8.50	.....	7.12	.....	10.00
Means	9.21	9.67	13.06	17.13	16.00	12.18	10.56	9.16	7.92	7.32	8.23	9.83

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Readings of the gauge at Kampsville Lock.

[Plane of reference: Low water of 1879.]

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	0.57	0.82	3.68	8.97	11.47	3.98	4.65	1.05	0.93	0.00	—0.20	1.40
2	.65	.82	3.80	8.97	11.42	3.67	4.80	.95	.92	0.00	— .25	1.38
3	.78	.92	3.85	8.78	11.35	3.40	5.00	1.17	.88	0.00	— .20	1.15
4	1.17	1.15	4.17	8.67	11.28	3.43	5.20	1.32	.77	—0.02	— .15	1.30
5	1.42	1.17	4.07	8.65	11.17	3.65	5.23	1.30	.68	— .10	— .10	1.12
6	1.60	1.10	4.10	8.72	11.00	3.92	5.03	1.10	.62	— .10	— .08	1.12
7	1.65	.95	4.10	8.83	10.87	3.88	4.52	.90	.58	— .05	— .10	1.32
8	1.57	.82	4.17	8.98	10.70	3.87	4.17	.75	.53	— .05	— .05	1.40
9	1.55	.88	4.22	9.08	10.50	4.13	3.95	.63	.50	0.00	.05	1.50
10	1.45	.93	4.27	9.30	10.25	4.55	3.90	.53	.45	0.00	.12	1.55
11	1.35	.88	4.30	9.57	10.03	4.78	3.92	.55	.40	0.00	.15	1.62
12	1.40	.87	4.30	9.88	9.80	5.08	3.80	.82	.35	— .05	.15	1.63
13	1.57	.90	4.27	9.95	9.47	4.83	3.52	1.05	.35	— .05	.10	1.70
14	1.60	.90	4.23	9.83	9.15	4.17	3.18	1.00	.30	— .07	.05	1.75
15	1.45	.93	4.20	9.63	8.85	3.75	3.02	.97	.30	— .12	.12	1.82
16	1.46	.95	4.15	9.55	8.45	3.67	3.08	1.15	.23	— .20	.32	1.85
17	1.38	.95	4.15	9.87	8.00	3.70	2.92	1.80	.20	— .20	.37	1.85
18	1.30	.90	4.22	10.57	7.53	3.75	2.83	3.10	.20	— .15	.45	1.92
19	1.23	.92	4.35	10.75	7.07	3.77	2.48	3.35	.18	— .23	.45	1.98
20	1.15	1.37	4.50	11.12	6.68	3.92	2.20	3.23	.13	— .25	.53	2.03
21	1.15	1.95	4.75	11.32	6.67	4.28	1.95	3.05	.12	— .23	.60	2.05
22	1.10	2.40	5.08	11.43	7.47	4.55	1.88	2.90	.12	— .15	.82	2.05
23	1.02	2.95	5.40	11.68	7.10	4.87	1.72	2.55	.10	— .15	1.55	2.03
24	.95	3.20	6.10	11.97	6.75	5.18	1.58	2.15	.10	— .15	1.70	2.02
25	.90	3.30	6.88	12.13	6.20	5.35	1.35	1.77	.10	— .10	1.65	2.12
26	.90	3.27	7.31	12.15	5.68	5.28	1.23	1.47	.10	— .05	1.55	2.12
27	.87	3.42	7.57	11.98	5.33	5.02	1.18	1.20	.10	— .05	1.53	2.00
28	.90	3.52	7.92	11.87	5.07	4.85	1.05	1.02	.10	— .08	1.48	2.00
29	.92	.....	8.38	11.73	4.85	4.72	1.07	1.02	.10	— .05	1.35	2.05
30	.78	.....	8.72	11.57	4.60	4.68	1.17	1.05	.05	— .15	1.20	2.02
31	.75	.....	8.85	.....	4.25	.....	1.20	1.03	.....	— .15	.....	2.00
Means	1.18	1.54	5.16	10.25	8.36	4.29	2.99	1.48	0.35	—0.09	0.51	1.74

COMMERCIAL STATISTICS.

The following figures are taken from the annual report of the Merchants' Exchange, St. Louis, Mo., for calendar year 1891:

Arrivals and departures of steamboats and barges at St. Louis, Mo., via Illinois River.

Month.	Arrivals.	Departures.	Month.	Arrivals.	Departures.
January	.....	.....	August	20	19
February	.....	.....	September	11	9
March	9	7	October	3	.....
April	22	19	November	9	8
May	15	11	December	1	.....
June	11	10			
July	14	15	Total	115	98

Receipts and shipments, in tons, via Illinois River, at St. Louis, Mo., 1891.

Month.	Receipts.	Shipments.	Month.	Receipts.	Shipments.
January	.....	.....	August	2,675	675
February	.....	.....	September	880	490
March	3,340	550	October	250	.....
April	14,310	670	November	1,610	.....
May	3,655	620	December	.....	.....
June	1,300	505			
July	3,170	795	Total	31,190	4,305

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The following figures of business passing through the Henry and Copperas Creek locks were furnished by the collectors stationed at the locks.

Henry Lock.—The aggregate tonnage of boats passing through this lock during the calendar year 1891 was 63,103 tons.

The commodities carried through the lock were as follows:

	Tons.
Grain	1,278
Ice, coal, and hay	8,774
Miscellaneous	151
General merchandise	247
Total	10,450
Passengers carried	2,939

About 25 per cent should be added to the above for freight and passengers carried over the dam at high-water stages.

Copperas Creek.—The aggregate tonnage of boats passing the lock was 45,862 tons. Vessels reported at Henry are not reported at Copperas Creek.

La Grange Lock.—At La Grange Lock the aggregate tonnage passing the lock during the year was 138,670 tons; freight, 42,000 tons.

The total tonnage of the Illinois River during the fiscal year 1892 appears to have been approximately 300,000 tons, showing an increase of fully 100 per cent over the preceding year. This is due not only to the more abundant crops, but also to the ice trade, the past winter being the first for several years during which merchantable ice has been gathered.

COMMUNICATION TO THE BOARD OF TRUSTEES OF THE CHICAGO SANITARY DISTRICT, SUBMITTED BY MR. WENTER, MEMBER OF THE BOARD, APRIL 21, 1891.

Memoranda in relation to main outlet, sanitary district of Chicago.—These memoranda relate to the following topics: (1) The Worthen-Newton estimate; (2) prices for work; (3) estimate for various channels; (4) capacity for dilution of sewage; (5) available revenue; (6) large expenditures by cities.

They are presented as a series of notes for the purpose of showing that the sanitary works called for by the law are within the resources of the community and are necessary.

1. THE WORTHEN-NEWTON ESTIMATES.

Their channel followed the Ogden-Wentworth ditch and the west bank of the Desplaines River. The dimensions were 180 feet wide and 18 feet deep with a grade of 5 inches per mile. The estimate of cost was $25,700,000, not including land damages or passages of the water through Joliet.

This estimate is excessive and for the following reasons: (1) The location follows higher ground than is necessary; (2) the route covers more work than any other line that can be considered; (3) the proportions of the channel are not the best for economy; (4) unnecessary retaining walls are provided; (5) the prices for work are nearly double those for which this work can be done, as compared with other works of the world.

In addition, it may be stated that the location is not well suited to the needs of the city, and a better and less expensive channel can be made for navigation.

The following table compares the prices used with those adopted by the Hering Commission of 1886–'87, consisting of Rudolph Hering, Benezette Williams, and S. G. Artingstall.

Price per yard.

Class.	Worthen-Newton.	Hering Commission.
Rock	$1.20	$0.75
Hardpan, etc	.60	.30
Clay	.30	.15

The prices for work were carefully considered by the Hering Commission and the data in regard to extensive works, since gathered, sustain those prices as sufficiently liberal.

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2. PRICES FOR WORK.

Solid rock in narrow railway cuttings, where disposal of material is difficult, is now being done at 70 to 90 cents per yard.

Rock is now being quarried at Lemont for $2 per cord of 13,000 pounds, or 100 cubic feet solid. This is at the rate of 54 cents per yard. It is delivered on board cars for $1.08 per yard and has actually been delivered in this city for $1.62 per yard, or $6 per cord.

Rock for wharves on the Mississippi River is actually delivered on board barges for 50 to 75 cents per loose yard for quarries on the banks of rivers.

In the Amsterdam Canal of Holland (1865–'76) 21,000,000 yards of material were moved at an average rate of about 4 cents per yard.

In the St. Petersburg Canal (1878–'85) 63,000,000 yards were moved for about 5 cents per yard.

The St. Lawrence has been deepened over a length of 40 miles between Montreal and Quebec, from a depth of 10½ feet to 27½ feet; material clay, sand, hardpan bowlders, and some ledge rock. Aggregate cost for last ten years work, 13 cents per yard. The clay has been down at from 3 to 6 cents per yard.

The records of several dredges on harbor works in Europe and Australia gives rates of from 4 to 6 cents per yard in free material and at American prices.

The Lake Erie and Ohio River ship canal commissioners of Pennsylvania recently reported on a canal 100 miles long from Conneaut on Lake Erie to Beaver on the Ohio River. Total excavation 43,282,475 yards, at $8,656,495, or an average of 20 cents per yard for all classes of material. Much of the work was estimated at 12 cents per yard.

The Manchester Ship Canal involves 47,250,000 yards, one-sixth of which is rock. Total cost of canal complete, $30,000,000. Less than half this amount is for excavation, but the figures are not reported.

The North Sea (Holstein) Canal involves 67,000,000 yards of excavation, and the total cost is estimated at $39,000,000. No details as to cost of excavation are given.

Various harbor work in the United States is being done at 10 to 20 cents in limited quantities.

The information available indicates that with special machinery and full preparation, the work can be done as cheaply as similar work has ever been done, or well inside the prices of the Hering Commission, viz, 15 cents for clay, 30 cents for difficult dredging, and 75 cents for rock.

3. Estimate for various channels.—Channel from Ashland avenue to Lockport, 30 miles.

Capacity per minute.	Width.	Depth.	Grade per mile.	Excavation.	Cost of excavation.
Feet.	*Feet.*	*Feet.*	*Inches.*	*Cubic yards.*	
210,000	160	10	6.84	22,196,000	$9,917,000
300,000	160	10	15.60	32,231,000	15,817,000
300,000	160	14	4.44	22,882,000	9,721,500
600,000	160	18	7.00	29,685,000	13,136,000
600,000	160	21.6	3.62	29,086,000	12,263,000
600,000	200	18	4.00	30,169,000	*14,931,400
600,000	180	18	5.00	37,914,830	†14,228,900

* Hering Commission.
† Worthen-Newton.

Prices of rock, 75 cents; hard material, 30 cents; clay 15 cents. All the estimates above are on the same basis as to prices per yard.

Between Ashland avenue and Lockport, right of way, bridging, and miscellaneous will add $5,000,000 to each of the foregoing estimates for the total. One million may be added for passing the volume of water from Lockport to Lake Joliet.

Below Joliet the entire value of landed property throughout the Illinois Valley is estimated at less than $3,000,000. Any damage from overflow will be but a fraction of this.

It will be noticed that a channel 10 feet deep for either 210,000 or 300,000 cubic feet is more expensive than one 14 feet deep. It will also be noticed that a channel to carry 600,000 cubic feet and 21.6 feet deep is cheaper than a channel 18 feet deep and of the same capacity. It will also be noticed that to double the capacity from 300,000 to 600,000 only adds $2,541,500, or some 17 per cent to the total between Chicago and Lockport.

The reason for these results are due to grade and its effect on the amount of rock excavation at the lower end of the channel.

The best proportion of channel can only be told after full borings have been made.

It will be noticed that the Hering channel, with a width of 200 feet, cost little

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more than the Worthen-Newton channel with a width of 180 feet. This estimate involves more rock than is since found to exist and is accordingly high.

The actual channel is not likely to exceed these estimates, as the actual rock is less than that assumed.

By comparing the quantities with the total for the Manchester Canal, some ideas of outside limit of cost may be obtained. That work involves a vast amount of docking, bridging, and locks, and is greater than a channel 25 feet deep carried clear to Lake Joliet, complete with locks and revetment.

4. CAPACITY FOR DILUTION OF SEWAGE.

The best results of investigation up to the time the law was passed placed the dilution at 20,000 cubic feet for each 100,000 inhabitants, as needed for a sanitary condition, and the probable population at 3,000,000 in 25 years.

During the past season the canal carried about 50,000 cubic feet per minute up to December last. The amount of organic matter carried out by the canal at that time was about 250 tons per day. This was not far from the amount going into the South Fork alone at that time, and was probably less than one-fourth of the total organic waste produced by the city as sewage. This can not be definitely known until a sanitary survey is carried over the city.

It may be stated that if all the sewage of the city was made tributary to the canal before decomposition had set in, then a volume of 200,000 cubic feet per minute sent out of the city would not improve the condition now found to exist in the canal.

The provisions of the law do not require unnecessary dilution, and it may be wise to provide the full amount of 600,000 cubic feet from the beginning.

No engineer of this Board, nor of any previous investigations, have recorded an opinion that the dilution mentioned is not required for a sanitary condition, and no engineer has said that with this dilution, the Illinois River would be fit to drink.

5. AVAILABLE REVENUE.

Assume that the assessed valuation for 1891 will be $220,000,000, and that the valution increase at the rate of 5 per cent each year, which is certainly a conservative estimate, at the end of ten years the valuation would be $341,292,000. This would permit a bond issue of about $17,000,000 in ten years were it not limited in the law to $15,000,000.

If these bonds are issued at the rate of $1,500,000 per year for ten years, and the rate of taxation of one-half of 1 per cent is applied, then the total realized during the ten years from bonds and taxation would be $25,535,000 after paying interest currently on bonds issued at the rate of 4 per cent.

If one-twentieth of the bonds are retired each year by money from the tax levy, then the available revenue in ten years will be less, or about $20,000,000 to $22,000,000, according to the magnitudes of the annual issues and the fiscal policy which may be adopted.

It is well not to lose sight of other sources of revenue which may be made available on a broad range policy.

1. Special assessment will be available for lateral channels which seem a local territory, and perhaps to a limited extent on the main channel.
2. Property values may be created by applying the material excavated. The possibility of large resources are covered in this.
3. Coöperation on the part of the United States. This seems to have been lost sight of.
4. The dockage and water power will be sources of revenue in time, though this may be of slow development.

It is impracticable to construct an economical channel for drainage which is not also a good navigable channel, and the United States should be willing to put into this the cost of the 8-foot channel which its officers have estimated and recommended.

A practical fiscal policy should be possible under this law, and relief can never be had sooner than by making a beginning.

The sanitary project of this city is a necessity, and well-considered investigation has determined that the ship-canal solution is the only one practicable and within the financial resources of this city. The problem must be solved or this city must stop growing.

6. LARGE CITY EXPENDITURES

Cincinnati put from twenty-five to thirty million into the Cincinnati railway. So far as direct revenue is concerned, the capital is largely sunk, though indirectly the city is richly repaid.

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Chicago has put the same amount in her park system since 1869, and has not felt the burden, nor does she begrudge the expenditure.

This city expends about twenty-five million each year for all purposes, including the money for special assessments. (See last city report.) This is as much as it may ever be necessary to raise under this law and is spread over a term of years.

Considering the sums spent by other cities for public works, the sanitary project at twice the cost ought not to be regarded as serious.

REPORT OF COMMITTEE ON ENGINEERING TO BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO, SUBMITTED JANUARY 9, 1892.

GENTLEMEN: On December 12, 1891 (page 298 of proceedings), your honorable board instructed the engineering committee as follows:

"*Resolved*, That the engineering committee be instructed to carefully examine the work of the engineering department and any proposed plan of operations and make such recommendations as will expedite the beginning of actual construction upon the main channel between Chicago and Joliet, and secure the completion of the entire channel at the earliest date and with the greatest economy, and that said committee report as soon as practicable."

This resolution calls for a comprehensive review of the work of the district and the formulation of a policy for the consideration of the board. The committee has made full use of the time at its disposal, and now submits a general report, reserving detailed recommendations for further consideration.

The committee has consulted maps, diagrams, and reports, conferred with the chief engineer, heard experts upon the relative cost of rock excavation under water and by dry quarrying and listened to the objections offered to the Chicago end of the route as adopted, on behalf of the several railway corporations interested. In addition, each member has used every opportunity to inform himself upon the matter in hand.

PAST POLICY OF THE BOARD.

Your committee can not ascertain from the records or by personal inquiry that the action of the board has been guided heretofore by a definite policy or a specific plan of operations. If so, it was not a matter of general information.

The following have appeared to the committee:

(1) The estimates of the engineer contemplated fixed bridges throughout the route from Chicago to Lockport. The requirement of swing bridges and a navigabe channel was one not anticipated by the railways, as appeared in the hearings by the committee.

(2) The channel of a capacity of 600,000 cubic feet per minute through the rock begins at Sag, when the law requires that it should begin at Willow Springs, 5 miles nearer Chicago. (See section 23 in regard to "territory with a rocky stratum.")

(3) The dimensions of the channel, its depth at the starting point, and its grade, are not matters of official record, nor are the works proposed for the development of water power below Lockport. In fact there are no proper records which indicate the plans of the board. So far as the committee can infer, one foot only is allowed for fall in a distance of 7 miles from the lake through the river to the stock yards, and the grades are relatively much less than those adopted by Messrs. Worthen and Newton. It is extremely doubtful if the channel as designed will pass muster under section 27 of the law.

(4) Every engineer of the board has suggested that work should begin on the rock cut, between Sag and Lockport, as the completion of this section requires the longest time and is a measure of the period when the entire work may be made available. Statements have been made which led to the inference that condemnation proceedings here would require one year. It has been ascertained that they can be completed for practical purposes in sixty days.

(5) The attention of the Board was largely concentrated on the work between the stock yards and the Desplaines River at Summit, a section that would have been useless for several years until the remainder of the work could be completed. It was intended to erect pumping works at Corwith, and it is inferred that pumping works were also to be erected at Summit to throw water into the Desplaines River, a purpose certainly contrary to the spirit of the law. The report of the engineering committee, July 11, 1891 (page 201 of proceedings), seems to contemplate this section as the only work prior to 1893.

The above, and all that has come to the attention of the committee, is in harmony with the following:

That the work immediately contemplated was a channel by the most direct route from the South Fork to the Desplaines River, near the Ogden-Wentworth Dam, the

line as adopted, said channel to be spanned by fixed bridges and to be operated by pumping works to the capacity of the canal at Corwith, and similar works at the Desplaines River, the work to be completed during 1892-'93. No investment was to be made on the remainder of the work.

THE ROCK CUT.

As the estimated cost of 15 miles of work, covering the rock cut between Willow Springs and Lockport, is about 80 per cent of the entire cost of excavation between Chicago and Lockport, and as the time required to do this portion of the work is longer than that required for any other section, the committee has given this portion of the route special attention as the progress here made is a measure of the time when the entire work may be made available.

The line adopted follows the course of the Desplaines River, and it was proposed to excavate the rock under water. The chief engineer asserted that no other location was feasible, and that, in any event, the rock could be excavated as cheaply under water as by dry quarrying. Upon diligent inquiry, he failed to adduce any experience in justification of his conclusions or in support of the price used in the estimate ($1.10 per cubic yard) which appeared to be entirely too low for the character of rock (Niagara limestone), nor did it appear that the chief engineer had any experience of his own upon which to base an opinion.

The committee was not prepared to accept these conclusions. The method proposed seemed liable to serious interruption by ice and flood and to be subject to every contingency, thus rendering very uncertain the time of completion and the cost, and the channel itself would be left in very irregular condition, thus seriously impeding the flow of water and necessitating a larger section to carry the requisite volume. It was doubted whether the method would be followed in actual practice, and it seemed probable that the work would be done better, quicker, and more cheaply by dry quarrying during such months of the year as the cut could be maintained free from the waters of the river.

On the other hand, could a location be obtained capable of protection against the river and all surface water, except what fell directly from the clouds, and should the rock itself not be water-bearing to the extent of requiring a large outlay to maintain dry quarry pits, the work could be prosecuted continuously throughout the year and free from contingencies, thus greatly expediting the completion of the work and insuring the very lowest prices.

The matter was of such grave import that the committee sought the advice of experts, and men of the widest experience cheerfully responded to the request of the committee either in person or by letter, as Gen. Charles Fitz Simons, the McArthur Brothers, John Dolese, of Dolese & Shepard; Mr. Earnshaw, Mr. Merriman; Gen. O. M. Poe, U. S. Engineer Corps, of Detroit, and Dunbar & Son, of Buffalo.

It was the unanimous opinion that when dry pits could be readily maintained the work could be done much cheaper and more expeditiously by dry quarrying, and that under such condition the work could be prosecuted throughout the year. Such testimony as was specific indicated that it could be done by this method for one-third to one-half the cost of under-water work. Such testimony as was given in regard to the rock lying between Sag and Lockport, and such other information as the committee has gathered, indicates that the amount of quarry water to contend with over these 10 miles will be small, and not an item of moment in the cost of the work. Over these 5 miles from Willow Springs to Sag the rock is relatively small in amount and overlaid with drift, and no conclusion is offered at this time.

Your committee finds that between Sag and Lockport there is considerable latitude for the choice of a route that can be protected from surface water at comparatively small expense and that will afford ready drainage for any quarry water that may require pumping; and it is probable that such routes may be considered; the total amounts of rock will not greatly differ.

The probable saving ranges in the million according to the method of work that may prove expedient and the contingencies involved in the present location, and the time required may be reduced and made an element of certainty. Your committee, therefore, urges an immediate reconsideration of this section of the route, and the preparation of plans for its protection from surface water.

THE RAILWAY OBJECTIONS.

In view of the determination of the Board to make the channel available for navigation as required by law, the location adopted from the South Fork to Summit became a matter of serious moment to the railway corporations which must cross the same by means of swing bridges, and especially so in proximity to yards and junctions. The committee, therefore, gave three hearings at which all the corporations interested were fully represented.

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The route between Chicago and Lockport is crossed at eight points by ten distinct lines, belonging to six corporations, and seven of these points are within the first 9 miles. The Santa Fe Railway is crossed four times, three crossings of the main line and one at the throat of their large yard at Corwith.

On any route selected there will be railway crossings, and the number of these on alternate routes can not be reduced below seven lines crossing at four points, to eight lines crossing at six points.

The constructive cost of the first 9 miles of feasible routes will not greatly differ, and the difference in cost of right of way will probably be far less than the variation in claims for railway damages, so this factor becomes of prime importance, except as it may be outweighed by considerations which pertain to the efficiency of the channel.

Your committee finds that the railways are not disposed in any way to needlessly embarrass the work. They regard a drawbridge as a serious matter and insist that such structures shall not be unnecessarily introduced in their lines and that they be located, if practicable, at such points as to occasion the minimum of inconvenience.

The route adopted has been characterized as one that inflicts the maximum possibility of damage between the waters of the Chicago River and Summit. At Corwith the route crosses the throat of the main yard of the Santa Fe system, the canal, and junction point of three railway lines, all in a short distance. The situation is capable of some amelioration. The Santa Fe Railway could be relocated for 5 miles to the north of the proposed channel between Corwith and Summit, thus avoiding two main-line crossings, but the position of the yards and junctions would not be materially modified. It is claimed that the value of this yard would be destroyed and a yard in some other locality necessitated, the entire cost of which would fall upon the district, an item in itself stated at over $1,500,000. This situation may be avoided or bettered by a route to the south of the yards, by the Illinois and Michigan Canal, or by one to the north of the canal.

The crossing at Western avenue and Thirty-ninth street is only less serious. Here are encountered the tracks of the Northern Pacific (not yet laid), the Panhandle, and the Stock Yards Company leading to their railway yard. It is a waiting point for trains, and bridges would seriously embarrass the business to the stock yards, as the point is now operated. The situation is capable of some amelioration, but not to the extent of reducing the point to the status of the main lines without radical rearrangement. This may be possible, but the situation must be met in any route from the South Fork.

The route adopted was probably the most available from the South Fork to the vicinity of Summit, for the purpose of pumping works at the canal crossing and at the Desplaines River, and was not intended for navigation. It certainly could not have been more objectionably located for the latter purpose. It is suggested by the chief engineer that the West Fork, to the junction point near Crawford avenue, was to be utilized as the navigable connection with the Chicago River, but no record of such intention is found in any report or proceeding, and this view is not in harmony with the estimates for fixed bridges over the entire route and with the channel of full section carried through to the South Fork.

The whole question of a route at this end should be reconsidered. The constructive cost should be reëstimated, the right of way appraised, and the railway damages valued for each line that may be available. On any line that may be adopted, the final determination of the basis of railway compensation is likely to be a matter of tedious litigation.

The cost is not, however, the only criterion. Within limits of cost, considerations which pertain to the efficiency of the channel and its adaptation to future needs should also govern. Some of these may be stated without further argument at this time.

(1) The channel should effectively remove the sewage without expensive adjuncts and auxiliaries which require large expenditures for operation and maintenance, thus making the efficiency dependent on the whims of an annual appropriation bill.

(2) The plan should contemplate the easy development of the water supply in excess of the capacity of the Chicago River when the occasion therefor shall arise, as contemplated by the law.

(3) All conditions should be avoided which will in any way militate against the fullest development of a navigable route from the lakes to the Mississippi, or the development of a deep-water harbor. While these are not issues immediately pending, they can not be ignored. The only feasible line for a waterway between the basin of the St. Lawrence and that of the Mississippi is by the Chicago divide, and the only hope for a waterway in this generation is through the operations of this district, and for this object we may confidently enlist the aid of the United States in proper time. The deep-harbor question may be best and most cheaply solved through the works of the district when the occasion therefor may arise.

Proper consideration has not been given to the Chicago end of the route, and for

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this purpose the matter should be given the most deliberate judgment. The committee has no fear that the completion of the work will thereby be delayed or its cost increased; in fact, such a course is likely to diminish the actual total of expenditure during the period for which the bonds will be issued.

OTHER SECTIONS OF THE ROUTE.

Any changes in the location of the section of 10 miles lying in the Desplaines River valley, between Summit and Sag, will depend largely upon the changes made in the rock section below Sag, and in the Chicago end this side of Summit.

The line runs through material varying widely in character and subject to all the contingencies of the Desplaines River. The channel for the 5 miles below Willow Springs will be partly in rock and will be necessarily slow in execution. The committee has not given the attention to this section of the route which would warrant advice at this time, and especially as any changes will depend in some degree upon the action taken upon the sections below and above.

The work necessary below Lockport is relatively small, not requiring a long time for its execution, though condemnation proceedings may be somewhat tedious. The plans contemplate the development of water power. It is submitted that all rights in the premises will be guarded by securing the right of way, and that the plans for such development should be in accord with the future requirements of a navigable channel. The work below Lockport is preeminently a matter in which to enlist Federal cooperation, and before any necessity arises for treating this section ample time will be permitted to define the policy of the district in this regard.

The relations of the Chicago River system to the works of the district are not yet determined, and surveys will be required for this purpose.

It is doubtful whether a velocity of over 1¼ to 1½ miles per hour through the river can be tolerated with due regard to the interests of navigation or the stability of the channel, with so many necessary obstructions in piers and angles. Some 400,000 cubic feet per minute passed through the South Branch in the flood of 1887, but the velocity at local points was excessive and the water at Bridgeport stood some 4 feet above the lake.

The channel can be greatly improved at localities and probably made available for a volume of 300,000 cubic feet per minute, but beyond this the cost is likely to be so large as to make a channel in some other locality a measure of economy when the occasion therefor arises.

OUTLINE OF POLICY.

The policy of the district is governed by the time when the works as a whole may be made available and the financial operations by which this result may be achieved within the resources of the district and at the least cost.

The 10 miles of continuous rock cut between Sag and Lockport demands the longest time in execution. This will require one thousand actual working days, or four years, and work should begin in the next six months. The 5 miles from Willow Springs to Sag, in part rock, will be scarcely less tedious, and actual work should also begin this season. Other items will not add over 10 cent to the cost of excavation, so the preparation for work is not a serious matter. These two sections will include about 80 per cent of the total cost for excavation between Chicago and Lockport.

The work from Chicago to Willow Springs, 14 miles, can be completed in 1896 if actually begun in force in the spring of 1894. The preparation of plant will require some time, and this should be put under way in 1893. The cost of excavating this section will be exceeded by cost of right of way and damages. The adjustment of all questions in issue at the Chicago end will require considerable time.

The work below Lockport can be completed, if undertaken, in 1894 or early in 1895. The litigation here will involve some delays. The plans should be in harmony with future development for navigation. The water power will be conserved in the right of way.

The work in the Chicago River can also await the latest date, though the plans for its development should be early matured, so that the new bridges built by the city and any changes made may conform to future requirements.

The general plan of operations outlined is calculated to make the shortest possible investment for the funds prior to the actual completion of the work.

The cash now in the treasury ($720,000) will cover the necessary cost of preparing the work from Willow Springs to Lockport, and the amount to be received in taxes during the year ($1,050,000) will cover any work of construction that can be undertaken this season.

The amount required for the work outlined is not yet a subject of close estimate. The section from Willow Springs to Lockport will probably fall inside of $11,000,000, and the section from Chicago to Willow Springs should not exceed $7,000,000, much depending on the matter of damages, a total of $18,000,000. Below Lockport

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$1,000,000 may be sufficient for present consideration. The work in the Chicago River is an uncertain item, but certainly $1,000,000 will greatly better the stream for the uses of the district and for navigation.

Through taxes, bonds, and special assessments not less than $20,000,000 may be made available, so there is no present reason to suppose that the resources will be inadequate.

After the main works outlined are completed, any further development will come logically and progressively, without entertaining any serious financial question, provided the general plan is now properly matured.

RECOMMENDATIONS.

Your committee has the honor to recommend as follows:

1. Reconsider the route from Sag to Lockport at once and prepare plans for protecting the same from surface water, with a view to beginning work on this section at the earliest practicable date.

The reconsideration of this section will require little if any field work prior to staking out the adopted line on the ground. It should be possible to adopt a new route and prepare plans for the same in sixty to ninety days, and actually begin work in June. Sufficient property can be acquired by that time.

2. Relocate the route where necessary between Willow Springs and Sag, with a view to beginning work this season. This may be done in sixty to ninety days after the Sag-Lockport section.

3. Reconsider the whole question of route from Chicago to Willow Springs, in the light of present needs and the requirements for future development.

Provision for actual construction on this section should be made not later than the latter part of 1893.

4. Reconsider the route and the treatment of the problem below Lockport.

Litigation here may require one year. Work need not begin until early in 1895. Meantime the plans may be matured in harmony with some plan for navigation with Federal cooperation.

5. Fix the conditions to be met through the Chicago River as soon as practicable, so that all structures and modification in dock line may conform to a general plan.

The city will doubtless cooperate in this policy so far as it has occasion to deal with the river in the interests of navigation. The work will be fragmentary and may involve some tedious litigation, and any opportunity for correcting the river at localities should be availed of. The larger part of the work, however, may be postponed should financial considerations render this expedient.

Your committee is persuaded that every energy should be bent to secure the actual beginning of work between Sag and Lockport, and that meantime every other consideration should be subsidiary. After this is begun ample time will be available for the careful consideration of other sections of the route, without delaying the completion of the work as a whole. We are also persuaded that such a course will apply the resources of the district to the best advantage.

CONCLUSION.

In view of some current misconceptions, your committee would add the following as bearing upon the character of the project as a whole:

(1) This solution of the sanitary problem was adopted because it was much the cheapest, involved little or nothing for maintenance and operation, and had collateral advantages as a waterway.

(2) The capacity was fixed by two considerations: (*a*) That the channel should provide the necessary dilution to maintain a sanitary condition for the probable growth of population during the time for which the bonds are issued, or until the work is paid for. (*b*) That it should be adequate, in conjunction with other works, to remove snow and rain water in floods, and thus prevent contamination of the lake at such times.

(3) It is not practicable, on account of excessive cost, to make a channel that will carry the requisite volume of water and at the same time be unnavigable. This is determined by the physical conditions. A channel flowing at a high velocity requires a high grade, thus increasing the depth of rock-cutting at the lower end. Such a channel will be unstable in the clay.

(4) For the required capacity a deep channel is less costly than a wide one. It is also subject to less variation in flow, by changes in the level of the lake, by floods, and by ice, and it is more easily regulated at the lower end on account of less fall.

These are the substantial considerations which determined the present general plan as outlined in the law. Fortunately, all these conditions are also in the interest of navigation. The only incident for actual navigation is proper railway and highway crossings.

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This law was matured after long consideration, and is explicit in its provisions. It lays down the conditions which must be met, and definitely prescribes the limitations upon capacity and size of channel. It is no part of the duty of this board to question these provisions, and it has no option other than to carry them out in accordance with their full spirit.

Very respectfully submitted.

LYMAN E. COOLEY,
WILLIAM BOLDENWECK,
JOHN J. ALTPETER,
Committee on Engineering.

The honorable the BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO.

REPORT OF MR. WILLIAMS, CHIEF ENGINEER, TO THE BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO, SUBMITTED FEBRUARY 17, 1892.

CHICAGO, *February 17, 1892.*

GENTLEMEN: On January 16 your honorable board passed an order as follows:

"*Resolved*, That the chief engineer is hereby instructed to submit, as soon as practicable, alternative locations for the route between Sag and Lockport, with comparative estimates in sufficient detail to determine the relative cost of the several lines that may be considered, and that he include in said estimates all collateral works and damages.

In complying with this order it is found that to make a proper preliminary location and estimate for alternate lines between the points named that will admit of the best method of treatment and be conformable to the sanitary district law involves a consideration of the work which will be necessary to improve, for the passage of water, the Desplaines River from some point above Lockport to the upper basin at Joliet and that which will be necessary in excavating the main channel between Sag and Willow Springs. I have hence exceeded the instructions to the extent of submitting alternative locations for the route between Willow Springs and the upper basin, with comparative estimates for quantities and cost for the whole distance, based upon the most economical channel of uniform depth. Within these limits is comprised nearly all the rock excavation on the line of the proposed main drainage channel from Chicago to the upper basin.

Each of the several lines considered in the comparative estimates have received similar treatment, and the estimates are based upon the same method of working, except so far as differences of location compel variations.

There are three distinct routes from Willow Springs to Lockport and four from a point above Lemont to Lockport covered by these estimates. At or about Lockport all four lines merge into one. These various lines are shown upon the accompanying map, which is made in two sections, the estimates being given in Appendix A. The fifth line shown on the map is considered wholly as regards a different method of treatment and receives separate consideration hereinafter.

Line No. 1 follows the location made by Mr. William E. Worthen to a point above Lockport, where there is a deflection into a line common to all routes. This line is situated almost entirely on the north and west side of the Desplaines River, striking the river only at a very few points.

Line No. 2 is on the location made by Mr. Samuel G. Artingstall, intersecting the common line at Lockport. It follows the bed of the river as closely as is consistent with a satisfactory alignment.

Line No. 3 is a new location throughout. As far as possible it lies on the south and east side of the Desplaines River, between the river and the Illinois and Michigan Canal. It necessarily crosses bends of the river in a few places, but in such a manner that with a comparatively small amount of excavation the river channel may be changed so as to protect the new work. It involves a new location of the Chicago, Santa Fe and California Railway for a distance of 22,200 feet, 6,000 feet of which the company is now engaged in making for the purpose of improving their line, leaving 16,200 feet to be changed should the route be adopted.

Line No. 4 and No. 4 A are still other new locations; the former following line No. 3 to a point nearly 1½ miles above Lemont, where it diverges, crossing the Illinois and Michigan Canal one-half mile below Lemont, and again crossing the canal about 1 mile above Lockport. This line involves a shifting of the tracks of the Chicago and Alton Railroad near Romeo, for a distance of 4,000 feet, and either the abandonment of the Illinois and Michigan Canal below the first crossing, or the carrying of that canal across the new channel in flumes, with a waiver of the navigability of the latter.

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No. 4 A is a variation of line 4 lying between the two canal crossings. It does not differ materially from the latter.

Line No. 5, as heretofore stated, is considered wholly with reference to a different treatment of the project from that proposed for lines 1, 2, 3, and 4. This difference of treatment is described in another place. This line starts at Willow Springs, coincident with line 2, and continues in that line a distance of 7,000 feet, thence in the same course to the west line of section 14, below Sag Junction, crossing the Illinois and Michigan Canal on the way, 3¼ miles below Willow Springs. Thence the line deflects northward into the Lemont tangent of the present canal produced; thence it follows the bed of the canal past Lemont, and continues in a straight course to the Romeo point, which it rounds with an easy curve, thence taking a straight course to Dam No. 1, at the lower end of the upper basin at Joliet. It follows close to line 4, east of the canal, and passes east of the wire mill at Lockport, and under the bridge of the Elgin, Joliet and Eastern Railroad. From Willow Springs to Dam No. 1 there are but two curves, the whole distance being accomplished by three tangents.

The adoption of this line will involve the reconstruction of the present canal in three sections aggregating a total distance of 26,000 feet. It involves two canal crossings, a change in the Chicago, Santa Fe and California Railroad for one-half mile, and a reconstruction of the Chicago, Alton and St. Louis Railroad in two sections aggregating in all 28,000 feet of double track. Like No. 4, it necessitates the abandonment of the Illinois and Michigan Canal, or the carrying of the same across the proposed new canal in flumes.

Within the range of the above described lines, almost the whole of the Desplaines River Valley is included, that can be said to be available for canal construction.

In the estimates of cost, given in Appendix A, for the first four lines that of the right of way has been excluded, except to state approximately the number of acres. The results are peculiarly notable in the small variation that there is between the lowest and the highest, viz, No. 3 and No. 1, respectively, which is slightly less than 5 per cent. Indeed, this variation is so small that without considering the question of right of way, facilities for working which the various lines present, and the probable hazard from floods in the Desplaines River, one would be in grave doubt as to which line to recommend. This doubt is still further increased when we consider that where the surface of the rock is overlaid with glacial drift, as it generally is from Willow Springs to Lemont, the profiles of the rock from which the estimates are made are not absolutely reliable, owing to the incompleteness of the borings, and that this unreliability exists probably to a greater extent with lines 3 and 4 than with either of the others.

Probably the surer and more conclusive way to arrive at a decision relative to these lines is by a process of exclusion.

COMPARISON OF 3 AND 4.

Comparing No. 3 and No. 4 it is seen that the estimated cost of the latter line is $271,752 greater than the former; the estimated cost of No. 3 being $11,740,678.

No. 4 for a part of its length has some advantage in the matter of exposure to floods of the Desplaines River, but on the other hand is exposed to all drainage from the south of the line for several miles. It is also 1,000 feet shorter. It will require, in order to prevent damages by overflow, the condemnation of 435 acres of land more than No. 3. It crosses the canal twice, which will be an obstruction in working, and involves the raising, complicated questions with the canal commissioners, since the canal will either have to be abandoned or carried in flumes across the new channel. The estimates are based on the proposition to abandon the canal, as to carry it across the channels in flumes would defeat the purpose of the plan.

In this comparison it should be borne in mind that the doubt which exists as to the relative quantities for some of the lines does not exist as between these two, for the reason that throughout that portion of their length where they follow different routes surveys of the surface of the rock and of the ground have been carefully made. It is only in the section common to each that the profile of the rock is not reasonably reliable. Hence, as between these two lines, I have no hesitstion in preferring No. 3.

COMPARISON OF 2 AND 3.

In comparing lines Nos. 2 and 3 it is seen that omitting right of way No. 3 is apparently $140.966 cheaper than No. 2, and that it is 1,600 feet shorter. It is also much less hazardous in the matter of floods, and is likely to be less subject to water in the excavation during ordinary stages of the river. During the construction of line No. 2 the river will be forced into a new bed for a considerable part of the way,

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which will not be thoroughly puddled and comparatively water tight, as the old bed is. The levee that must be built along the new channel will for a large part of the way fall in the bed of the old river, and the land will slope toward it rather than from it, rendering it more difficult to exclude water. In some places also the river must be forced into very narrow confines between the new canal and the Chicago, Santa Fe and California Railway. Indeed, in at least one place, either the line or the road will have to be changed.

It has the advantage of saving 600 acres in right of way and in land subject to overflow, which, at $100 per acre, makes it cost but little more than No. 3. Its alignment, however, is inferior, and if selected should be modified in places.

A careful balancing of the arguments for and against each of these two lines makes it clear that line 3 is much to be preferred to line 2, though for reasons other than those shown in the estimates. Indeed, estimates are incapable of showing the real differences between lines under conditions such as these.

COMPARISON OF 1 AND 3.

The difference in cost between lines Nos. 1 and 3 is apparently $539,375, omitting right of way. Line No. 1 is also 3,000 feet longer than No. 3. In the facility with which it can be protected from floods in the Desplaines River, line No. 1 is perhaps slightly superior to line 3; but it has the disadvantage of being on the north and west sides of the river, and hence exposed to the drainage from all the creeks and ravines and drainage areas tributary to the river. On the other hand, the canal protects line 3 by intercepting the drainage from the south and east, which would otherwise reach the new channel.

The lands which it will be necessary to condemn for line 3 are in excess of those for line 1 by 663 acres. Giving these lands an extravagant price will still leave the balance largely in favor of line 3. This line also has a better alignment than any that have been considered.

In thus analyzing the advantages and disadvantages of the several routes above described upon which estimates have been made, I am decidedly of the opinion that line No. 3 is the proper one to adopt for the main drainage channel.

The conclusion reached regarding the merits of the four lines under discussion stands independently of the manner of treating the problem after encountering the sloping ground just above Lockport.

Though the comparison of cost has been made upon the basis of completed work in each case, from Willow Springs to the upper basin, the fact that all the lines merge into one at Lockport, the plan below being common to all, still leaves the relative showing correct for any treatment that may be given.

That there may be a full understanding of what this plan is, and its merits, if any, it is presented with two other projects that have heretofore been proposed, covering the length of about 23,000 feet lying between the end of the 18-foot channel, as proposed by the late Chief Engineer, and the upper basin.

Plan 1.—Mr. Worthen's plan was to continue the main channel with a uniform slope along the line shown on the map, to a point opposite the upper basin, and from this point the water was to pass through Joliet by means of a 24-foot steel pipe. In lieu of this the water could be allowed to escape into the upper basin and the river channel from the basin down improved to the proper capacity. If this plan were carried out, the upper or lake level would be maintained as far as the upper basin, and incidentally an excellent development of water power secured. On the west of the river valley would be the high level canal, and nearly parallel therewith and from 25 to 35 feet below it the river bed and the upper basin to act as a tail race.

Plan 2.—Mr. Artingstall's plan contemplates an improvement of the river bed by excavating and revetting the sides, and by building three dams, which will allow a descent in as many stages. This plan would allow of a partial utilization of the water power, but without extensive subsidiary canals would not give a full development thereof.

Plan 3.—The present plan, the cost of which is given in the estimates, is to use sufficient of the waste excavation from the canal between Willow Springs and Lockport to build a water-tight bank 100 to 120 feet wide on top, from a point 9,000 feet above Lockport to the upper basin, confining the water between this bank and the high ground on the west side of the river. It is also proposed to waste a large amount of material on the west side of the channel formed by this embankment, and thereby limit the spread of the water. This plan will incidentally furnish as good a development of water power as it is possible to secure.

It is proposed to build this retaining bank to a height of 8 feet above datum and to let the water out into the upper basin through 5-foot cast-iron pipe sluices, controlled with gates. Such an arrangement will remove any possible chance of the bank being overflowed under the worst conditions.

The general scheme as outlined on the map is quite preliminary and to a consider-

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able extent nearly [merely?] suggestive; it can not be worked out properly in detail until the territory covered by it has been surveyed.

Indeed, it should be said that in this matter of the terminal, below Lockport, there are modifications which can be made in the plan, and probably will be made on fuller study, which it is premature to enter into here.

A comparison of the cost of covering this stretch of 23,000 feet, by each of the three several plans described is given in Appendix B.

The right of way required for plans 1 and 3 is the same, though it is impossible to state how much it is without considering the question with reference to the legal rights of the district to water power created by it. Plan 2 does not require so much land by about 670 acres.

In arriving at the results in Appendices A and B, it will be noticed that 11,000,000 yards waste is estimated as being hauled at 7 cents per cubic yard, and that 3,000,000 cubic yards of rock are allowed at a reduced price, and credit given it in Appendix B, plan 3.

This waste enters into the bank that confines the water below Lockport, into a bank for the Elgin, Joliet and Eastern Railroad, and into spoil banks west of the proposed canal, thus raising the land and limiting the spread of the water.

As to the rate of 7 cents per cubic yard, due to the haul of the material from the excavation to the place of deposit, it should be said that it has been arrived at by very thorough investigations and estimates made by Assistant Engineer H. B. Alexander, the results of which are embodied in a report from Mr. Alexander, which I submit herewith as Appendix C.

This rate is shown to be the difference in cost between wasting the material adjacent to the line of the canal, and hauling it into banks an average distance of 10 miles, full allowance being made for cost of track, equipment and operation. In regard to the cost of the road it should be said that the mere building of the roadbed without track and ballast is a part of the excavation of the canal, material from the channel being used to build the bank for the road. Such a bank, or something its equivalent, is necessary to protect the excavation from the floods in the river, so that the bank serves a double purpose.

The allowance of 10 cents per cubic yard on 3,000,000 cubic yards of rock is based on the theory that if all but this amount of the best quality of rock is permanently disposed of from the first, that contractors will be found, who in making bids will for the sake of owning this stone, take the work at a very low price.

There are large quantities, running into hundreds of thousands of yards, of just such stone quarried and sold every year in and about Chicago, and there seems little doubt that the reason why this waste rock has heretofore been considered of no importance arises from the immense quantity which might belong to a great number of persons and thereby become valueless from its very plentifulness.

The incidental advantages which will be derived and the ultimate profits which may be reasonably expected to accrue from carrying out this plan, run up into millions of dollars. Some of these may be summed up as follows:

1. By permanently disposing of all but about 3,000,000 yards of rock, this amount will, as heretofore stated, be of value, and the contractor, who may own it after the work is done, can dispose of it at remunerative prices, for ballast, for crib work, and rubble masonry; and will doubtless in submitting a proposition do so with this in view, making allowances to the benefit of the sanitary district. On the other hand, if the whole amount of rock is wasted, it will have little or no value to anyone, as the market will be glutted with cheap stone.

2. As far as possible, it should be the policy of the sanitary district to so dispose of excavated material as to leave the banks clear of spoil. Much value will accrue to the right of way for the canal if it is kept clear of waste banks; but if it is encumbered with a chain of mountains on each side, its value will be almost destroyed. Four hundred feet of right of way clear will be of more value than 800 feet cumbered with spoil.

3. By carrying out the proposed plan below Lockport a channel of full depth will be extended 4 miles further, and whatever the depth of the waterway which the United States Government may build to the Mississippi River, these 4 miles will be of great benefit, and, in dealing with Congress, as the sanitary district will ultimately do, it should receive recognition to the financial benefit of the district.

4. This plan furnishes means for the complete control and measurement of the water which passes down the river at all times, and will doubtless prove of great value in preventing actual damages in the river below in the time of excessive floods, and particularly in furnishing a check by which claims for fictitious damages may be met.

5. By carrying out this plan the sanitary district will own the best mill sites, and control the steadiest and most reliable water power in the Northwest.

A fall of 33 feet, which will generally obtain 300,000 cubic feet per minute, will furnish 18,000 horse power, and with 600,000 cubic feet per minute it will furnish

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36,000 horse power. At the very low price of $10 per horse power, the first quantity when leased will bring an annual rental of $180,000, which capitalized at 5 per cent is $3,600,000, while the greater quantity will capitalize at $7,200,000. That this power would be readily taken at these rates admits of little doubt. It should be borne in mind that the execution of the proposed plan creates this power without another cent of expenditure other than short flumes and pipes to conduct the water to the wheels.

Line No. 5.—Surveys and estimates are being made of Line No. 5, the location of which is hereinbefore described.

The estimates, when completed, will show the cost of this line by two methods of treatment.

(1) The main channel proper will terminate at a point above the lower crossing of the Illinois and Michigan Canal, at which place controlling gates and waste flumes will be built. Below this point the channel will become a tailrace, and the water will be conducted to the lower basin in the cheapest manner consistent with safety.

(2) Parallel banks will be built—one on each side of the line below the lower crossing of the canal, and as far down as a point just above the Elgin, Joliet and Eastern Railroad Bridge. There they will end in a cross bank forming the inclosed space. At this point waste flumes and controlling gates will be provided for.

The banks of the channel will be carried up to a height of 8 feet above datum. This method will accomplish to a considerable extent the same ends accomplished by the plan heretofore described, and which is included in the estimates for lines 1 to 4 exclusive.

Work was only begun on this line a few days ago, and as the results are not likely to affect the conclusions of this report in any way that can not be properly considered by the engineering committee as a part of the same, it is thought best to submit the whole question in its present stage, and let the new data go to the engineering committee direct and be conveyed by that committee to the Board, rather than to delay another week.

Respectfully submitted,

BENEZETTE WILLIAMS,
Chief Engineer.

The honorable the BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO.

REPORT OF MR. WILLIAMS, CHIEF ENGINEER, TO THE BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO, SUBMITTED MAY 4, 1892.

CHICAGO, *May 4, 1892.*

GENTLEMEN: My communication of April 20, relative to a board of consulting engineers has been returned to me with the direction from your honorable board that I submit in writing at the next regular meeting the specific points which such board should consider.

It is true that the rules, technically construed, contemplate that all issues shall be defined and reduced to writing before the appointment of a board of experts; but as the opinion was entertained that it is fully within the powers of your board to engage experts to act in any capacity which you may see fit to prescribe, the request was made, expecting that if granted it would be upon broad grounds rather than in a manner strictly in compliance with the rules.

When the communication was submitted no issues had arisen that could be defined, nor can any such arise until the whole question is presented in the light of the bids which have been invited. The hope was indulged that by the choice of engineers of recognized standing and ability to consider the subject in all its bearings, it might be possible to avoid all differences.

Though issues can not be defined before they exist, it is not impossible to state the points about which they may cluster in certain contingencies.

As is well known, bids have been invited on three propositions, and a comparison of the same will be necessary before awards can intelligently be made.

"Proposition 3" will give the cost of excavating and constructing the main channel complete, from Willow Springs to the upper basin at Joliet, waiving the right of way and a few collateral structures of relatively small importance.

"Proposition 1" will give the cost of excavating, but in order to be comparable with Proposition 3, the cost of drainage and of the transportation of about two-thirds of the excavated material must be added. The determination of this additional cost is important, and any conclusion of your chief engineer relative thereto, is not likely to receive universal assent.

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"Proposition 2" will give the cost of excavating and disposing of a part, and only a part, of the material required to be excavated to furnish a channel for water to the upper basin. A tailrace, some 5 miles in length, will have to be located and excavated. Where shall this race be, and how much will it cost to excavate it? These are important points which your engineer can hardly hope to determine in such a manner as to be satisfactory to all.

Again, the work, if carried out in accordance with the proposed plan under either Propositions 1 or 3, will ultimately develop a water power above Joliet of full 30,000 horse power, which will be utterly lost under Proposition 2. Will such a water power have any value, and if so, how much? And should it be considered at all in connection with the work of the sanitary district, however small its cost and however great its value?

By carrying out the work under either Proposition 1 or 3, a very large portion of the banks of the channel will be kept clear of spoil, while absolutely none will be left unincumbered under Proposition 2. Does any value attach to this consideration?

A navigable channel under propositions 1 and 3 will extend with deep water 5 miles farther than under proposition 2. Such a channel, or its equivalent, is a necessity to the navigation of the Desplaines and Illinois rivers, and without it the money being expended by the United States Government on the Hennepin Canal and the improvement of the Illinois River will be utterly thrown away. Should this receive any consideration in carrying out this work?

Should it be shown that such a contribution to the work which the Government has in hand can be made at a nominal cost—work which would cost the Government, if carried out independently, many times what it would cost the sanitary district if done in connection with the main excavation—may it not be worthy of an effort to secure Government coöperation to the extent of the extra cost? And might not a thorough consideration of all these questions by a properly constituted board of engineers be the initiatory step to such coöperation?

These are mere hints as to the good which may come out of such a board if wisely chosen. But in view of the fact that the sanitary district is engaged in a work which incidentally is contributing immensely toward the project of a waterway which the Government is expending money upon, may it not be the proper time to take a step which may lead to results greatly to the financial benefit of the sanitary district?

I am profoundly impressed with the importance of the questions which must be decided after the bids are received on the 8th of June—questions which it may appear will affect the interests of the sanitary district to the amount of several millions of dollars—and I believe that the only safe way to approach them is in the manner suggested. Should your honorable board reach the same conclusion, then I think that all unsettled questions connected with the work below Willow Springs, coming within the domain of the engineering department, should be referred to such board after your chief engineer shall have made a report upon the same.

Or what, as it seems to me, would be conducive to greater expedition and better results, the consulting engineers might act with the chief engineer in making a joint report.

Respectfully submitted.

BENEZETTE WILLIAMS,
Chief Engineer.

The honorable the BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO.

REPORT OF MR. WILLIAMS, CHIEF ENGINEER, TO THE BOARD OF TRUSTEES OF THE SANITARY DISTRICT OF CHICAGO, SUBMITTED JUNE 7, 1892.

CHICAGO, *June 7, 1892.*

GENTLEMEN: I beg to report hereby, in compliance with the order of your honorable board passed February 17, which is as follows:

"*Ordered*, That the chief engineer is hereby directed to make comparative and itemized estimates of three alternative routes (one of which shall be the Illinois and Michigan Canal) between the waters of the Chicago River at Ashland avenue and Willow Springs road, and that the route already located be considered in comparison with the said routes; and that the estimate on each line include structures, right of way, railway damages, and all supplemental works necessary to make the main channel fully effective; and that he report upon the whole subject as soon as practicable, without delaying the work below Willow Springs."

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The wording of the order with reference to "supplemental works" is perhaps susceptible of more than one interpretation. The meaning attached to it for the purpose of this report is that all supplemental works needed west of Ashland avenue are to be included, but that those east of the same are to be included only so far as is necessary to a comparison of the various routes, the purpose being to get, as near as possible, to the actual cost of the main channel and everything connected therewith between the waters of the Chicago River at Ashland avenue and Willow Springs, and the probable relative cost of supplemental works for the several routes east of Ashland avenue which will ultimately be necessary to make the main channel fully effective.

That is, under this construction of the order we only need to consider the supplemental works east of Ashland avenue to the extent necessary to determine upon the best location of the main channel west of the same, in view of all possible requirements for the future.

The various lines considered are shown on an accompanying map. They are as follows: (1) Ogden Ditch, Line No. 1; (2) Ogden Ditch, Line No. 2; (3) canal line; (4) South Fork and Ogden Ditch line; (5) South Fork and canal line; (6) South Fork line.

The designations for these lines are only distinctive in their location between Ashland avenue and Summit, the choice being confined to three beyond Summit, as hereinafter described.

Ogden Ditch Line No. 1 begins at the crossing of Ashland avenue and the West Fork and follows a straight course to near the west line of section 33, and thence in a straight course along Ogden Ditch to Summit.

Ogden Ditch Line No. 2 also begins at the crossing of Ashland avenue and the West Fork and follows the fork as improved to Kedzie avenue, whence it joins the line previously described.

The canal line begins at the Ashland avenue crossing of the Illinois and Michigan Canal and follows the canal throughout, to within a quarter of a mile of Willow Springs; or, if found desirable, it may leave the canal at Summit and take one or the other of the lines shown on the map.

The South Fork and Ogden Ditch line, the one fixed by an ordinance of the board passed August 5, 1891, starts from the west arm of the South Fork at Ashland avenue and follows west to Kedzie avenue; thence it takes a northwesterly course, crossing the Illinois and Michigan Canal just west of Corwith, and joins the Ogden Ditch line at about the middle of section 34.

The South Fork and canal line also starts from the west arm of the South Fork at Ashland avenue and follows directly west, parallel with and just south of Thirty-ninth street to its intersection with the Illinois and Michigan Canal; thence it takes the canal route to Willow Springs, being open to the same modification as the latter route beyond Summit.

The South Fork line starts at the intersection of Ashland avenue and Thirty-ninth street and follows a straight course to Summit, whence it may take any one of the three lines to Willow Springs.

Between Summit and Willow Springs, as before stated, three lines are under consideration, one following the canal and one on each side, parallel thereto; the considerations which will mainly determine a choice being the depth of the rock on the west line (borings for which are now being made) and the relative cost of dry and wet excavation for the bowldery glacial drift which will be encountered. Conclusions as to this portion of the route are deferred until the borings are completed.

The approximate lengths of these various lines to the end of the located channel at Willow Springs, starting at the center of Ashland avenue, are as follows:

	Feet.	Miles.
Ogden Ditch Line No. 1	73,500	13.92
Ogden Ditch Line No. 2	73,900	14.00
Canal line	73,100	13.84
South Fork and Ogden Ditch line	73,200	13.86
South Fork and canal line	71,700	13.58
South Fork line	70,900	13.43

In the appendix are estimates of the cost of the several lines, which includes excavation, right of way, bridges, canal, and railroad changes, and collateral works for channels of 300,000 and 600,000 feet capacity per minute, respectively.

The estimates for right of way were made by Mr. Joseph Donnersberger, whose valuations have been implicitly followed. (They have purposely been made higher than the usual market rates.)

The estimates for railroad damages and bridging were made by Mr. Isham Randolph, to whom all proposed changes were submitted, that the details pertaining to this branch of the subject should be worked up in the most practicable form by a recognized expert in such matters.

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Beyond Summit, for the purpose of a uniform comparison, the west line has been taken in each case. The footings of the estimates for the various lines begin as follows:

Description of line.	300,000 cubic feet per minute.	600,000 cubic feet per minute.
Ogden Ditch Line No. 1	$10,265,095	$12,099,763
Ogden Ditch Line No. 2	9,284,944	11,175,070
Canal line	7,865,963	9,746,018
Canal line, with narrow right of way to Summit	5,899,963	7,780,018
South Fork and Ogden Ditch line	9,455,954	11,330,708
South Fork and canal line	8,903,678	10,804,919
South Fork line	9,978,153	12,043,016

These amounts include the estimated cost of the main channel, with right of way, railroad changes, bridges, and supplemental works west of Ashland avenue, on the respective routes, but give no idea of the relative difficulties that may be encountered in securing right of way, or the relative injury to railroad property, which is not susceptible of estimate; nor do they give any information as to which location will best meet the present and future sanitary needs of the city, nor which one will be cheapest if necessary supplemental works east of Ashland avenue be included. They are, hence, far from furnishing a conclusive determination as to which route should be adopted.

To arrive at a just conclusion, the question should be considered more in detail under the following heads: (1) Facility and expedition with which the respective routes can be worked. (2) Right of way and obstacles to procuring same, exclusive of railroad properties. (3) Interference with railroad interests. (4) Value of property acquired by the sanitary district upon the various routes. (5) Supplemental works necessary to render the main channel fully effective to the extent contemplated by the sanitary district law, and the prospective incidental advantages in the way of a navigable waterway and improved harbor facilities which the various routes may afford.

1. FACILITY AND EXPEDITION OF WORK.

The estimates take cognizance of the relative difficulty of executing the work, as far as it is possible to do so, in the matter of quantities and cost per cubic yard; but they show nothing as to the time required to carry out the work on the several routes. They are based upon the theory that to the west line of section 7, near Summit, on each route, respectively, the excavated material will be removed by scows or barges and dumped into the lake, either as filling where needed along the shore or so far out in deep water as to be no obstruction. This method of disposing of the material is recommended because it is believed to be but little if any more expensive than the process of spoiling the waste, unless the spoiling can be done over a large territory by means of hydraulic dredges, and because land that may cost the district from $1,000 to $10,000 per acre will have too great a value after a navigable channel shall have been cut through it to be used as dump grounds.

Either of the Ogden Ditch routes, the canal route, and the South Fork and canal route can be worked in this manner with about equal facility as to time and expense of transportation, the necessity of constructing and using a lock at the entrance to the canal about offsetting what will be, at first, the less commodious channel of the Ogden Ditch. On either of these routes with the right of way secured in a reasonable time, and an adequate plant, the work can be prosecuted with sufficient rapidity to insure its completion by the time the rock cut below Willow Springs is done.

On either side of the two remaining routes having their initial point in the South Fork, particularly the southern one, much slower progress must be made because there is more material to be removed for an equal distance, and no channel exists to facilitate access to the work. Again, to provide temporary crossings for railroads and highways will be more difficult on these lines than in the case of the first four named.

The material to be excavated on the Ogden Ditch routes, barring the rock at Western avenue on route No. 2, can be more easily handled than on any other. It should be said, however, that the weight which is attached to the variation in the quality of the material, and the difference of the manner in which the work will have to be done on the several lines, finds expression in the rates used in the estimates. My conclusion is that the work can be executed in less time after the right

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of way has been procured on the lines following the Ogden Ditch and the canal than on any of the other routes.

2.—RIGHT OF WAY.

In estimating upon the right of a way a strip 800 feet wide has been included, with some exceptions. A much wider strip for a part of the way between Ashland avenue and Kedzie avenue has been taken for Ogden Ditch, line No. 1, as it is deemed necessary in changing the bed of the river to control completely the riparian rights, so far as they exist, along the West Fork.

On Ogden Ditch, line No. 2, for a part of the way, only one side of the West Fork has been included.

In order that the canal line may be at no disadvantage with other lines, a strip has been included on both sides of the canal reserve as far as summit, giving a clear width of 1,000 feet, for the most part, between the railroad rights of way as reëstablished. By the omission of the strip on the south of the canal reserve there will be 460 feet remaining for most of the way from Ashland avenue to a point one-quarter of a mile west of the center of section 8, and the estimated cost of the right of way will be reduced from $3,191,000 to $1,283,000.

On the South Fork and Ogden Ditch line and the South Fork and canal line the strip east of the center of section 2 is generally but 600 feet wide. There are, of course, other minor exceptions which can not be noted here. There is not, apparently, any reason why one route should be particularly preferred over another, so far as the condemnation of private property is concerned, except that with the canal line there will be a less number of property owners to deal with.

Should the sanitary district enter upon this line with the consent of the canal commissioners there will be ample room to work within the limits of the canal reserve until the condemnation proceedings for additional right of way shall have been closed, thus giving this line a marked advantage in time of beginning over any other. An increase of time also tends to decrease the cost of the work, so that, notwithstanding more tenacious ground on this line, I consider that the cost of the work will be no greater per cubic yard than on the Ogden Ditch lines.

3.—RAILROAD INTERESTS.

The constructive cost of railroad changes, the building of bridges, interlocking, etc., is given in detail in the estimates. These amount in the aggregate for each route, respectively, to the following sums:

Ogden Ditch, route No. 1	$830,000
Ogden Ditch, route No. 2	830,000
Canal route	923,000
South Fork and Ogden Ditch route	1,095,300
South Fork and canal route	1,047,000
South Fork route	998,000

As it is impossible to infer from the above figures all the advantages and disadvantages which one route may possess over another, from a railroad standpoint, the following comparison is instituted for each railroad or group of railroads, separately:

Union Stock Yards and Transit Company; Chicago and Northern Pacific; Pittsburg, Cincinnati and St. Louis.—The main tracks of these roads, lying in adjacent and parallel lines, are crossed by all the routes in about the same manner, requiring for each a six-track swing bridge or its equivalent. The Ogden Ditch lines alone cross them where there are now swing bridges, hence the consequential damages and entailed expenses to the operating companies will be less along Ogden Ditch than any other route. It should be said, however, that as yet there are but few vessels passing the Western avenue bridges, and that should the main drainage channel take some other route than Ogden Ditch the conditions are not likely to change materially.

All the routes starting from the South Fork strike the Union Stock Yards and Transit Company's Yards in such a manner as to render rearrangement necessary. With the plan as projected for this rearrangement it is believed that no permanent injury would be done to these yards.

Chicago, Madison and Northern; Chicago, Santa Fe and California.—The main lines of these roads would be crossed between Kedzie avenue and Summit by the Ogden Ditch line, and as now located by the canal line, half way between Ashland avenue and Western avenue. The canal line also crosses the branch road of the Chicago, Santa Fe and California Railway Company at the throat of the Corwith yards in such a manner as to be extremely damaging.

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The Ogden Ditch line also crosses the Santa Fe branch tracks north of Corwith, but not in a manner as to be particularly objectionable.

To remove these obstacles in the way of the canal line it is proposed to change the location of these two roads from their present point of crossing eastward, keeping them north of the canal and crossing the South Fork north of the proposed entrance to the main drainage channel, the new bridge crossing the South Fork thus becoming a substitute for the one now in use, and saving one bridge to these roads. To overcome the crossing at the throat of the Santa Fe yards it is proposed to remove the yards to the north of the main line, extending from Corwith to the Western Indiana belt, and to dispense with the present yards.

The South Fork and Ogden Ditch line crosses the Santa Fe at the throat of the yards, and cuts through property beyond in such a manner as to prevent a removal of the same as proposed for the canal line. It also crosses the main line in two places before reaching Summit.

The South Fork and canal line and the South Fork line cross these yards in such a manner as to damage them so seriously that it is considered necessary to provide for their removal in the same way as proposed for the canal line. It may be said that with the various changes made as proposed, the Ogden Ditch route is the only one which will affect the Chicago, Madison and Northern Railway. In this case, however, the injury done would be serious, owing to a radical change in the alignment, substituting curves for a straight track, as well as introducing a swing bridge.

The Ogden Ditch routes and the South Fork and Ogden Ditch route are the only ones which really damage the Santa Fe Railroad, except in crossing the old Grand Trunk branch, the latter route being so ruinous in its effects as to practically become prohibitory.

By the proposed change the Santa Fe system as a whole will be materially benefited by the adoption of the canal route.

Chicago, Alton and St. Louis.—This road is crossed only by the three South Fork lines. In these cases the crossing is such as to seriously interfere with the alignment, and is very objectionable. The shifting of the tracks in the manner projected for the canal line would do this road no injury, but, on the other hand, would ultimately greatly benefit it in a business way.

Chicago and Western Indiana Belt.—All the routes cross this road in substantially the same manner, leaving nothing to mark a preference for one route over another, except that the Ogden Ditch line comes at a bad point in the grade of the road.

Chicago and Calumet Terminal.—The road is crossed in the same manner and at the same place by all the lines.

A summary of the railroad bridges between Ashland avenue and Willow Springs on the various routes after the proposed changes have been made is given in the following table:

Name of railroad.	Name of route.				
	Ogden Ditch, 1 and 2.	Canal.	South Fork and Ogden Ditch.	South Fork and Canal.	South Fork.
Pittsburg, Cincinnati and St. Louis.	Double track	.....	Double track	Double track	Double track.
Union Stock Yards and Transit Company.	Four track	Six track	Four track	Four track	Four track.
Chicago and Northern Pacific.	.....	.....	.....	.....	.....
Chicago, Madison and Northern.	Double track	.....	.....	.....	.....
Chicago, Santa Fe and California (main line.)	do	.....	Two double track.	.....	.....
Chicago, Santa Fe and California, old Grand Trunk Branch.	Single track	Single track	Double track	Single track	Single track.
Chicago, Alton and St. Louis.	.....	.....	do	Double track	Double track.
Chicago and Western Indiana Belt.	Double track	Double track	do	do	do
Calumet Terminal	do	do	do	do	do

As a conclusion of the railroad problem it may be said that the indirect damages on the "canal route" are at a minimum, while on the "South Fork and Ogden Ditch line" they are at a maximum and next to prohibitory, so far as the Chicago, Santa Fe and California Railway is concerned.

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4.—VALUE OF ACQUIRED PROPERTY.

The number of feet of available water front which, on the lines and rights of way as proposed, will belong to the sanitary district between Ashland avenue and the west line of section 7, this side of Summit, and to which point it is proposed to keep the banks free of spoil, not including platted streets, railroad crossings, etc., are as follows:

	Linear feet.
Ogden Ditch, line No. 1	71,800
Ogden Ditch, line No. 2	67,200
Canal line	70,800
South Fork and Ogden Ditch line	73,700
South Fork and Canal line	71,800
South Fork line	69,900

From this it is seen that there will be but little difference in the value of the acquired property if the wide right of way be taken on the canal line; but should it be narrowed to 460 feet its value on this line would probably be reduced as much as 75 per cent.

5.—SUPPLEMENTAL WORK.

A comparison of the various elements coming under the first four heads affecting the choice of a route renders it apparent that, if nothing else were to be taken into consideration, the choice would inevitably fall upon the canal. Under this head, however, other considerations may affect the problem, but before entering upon them it should be premised that, so far as supplemental works east of Ashland avenue are concerned, there are practically but two routes, the group consisting of the two Ogden Ditch routes and the canal route constituting one and the three South Fork routes another; and, since all but the canal route from the first group and all but the South Fork and canal route from the latter have been eliminated, our further inquiries are concerned wholly with these two routes as affected by the works necessary to render the main channel fully effective.

It is essential to inquire into the sanitary condition and capacity of the Chicago River and its branches and to reach an understanding of the provisions which will be necessary to meet local sanitary needs when the city shall have grown to such magnitude as to tax the full-size channel as required by the sanitary district law.

SANITARY REQUIREMENTS.

Whichever route may be adopted for the main channel, the main river and the south branch will feel the direct effect of the current created thereby, though only the route leading from the South Fork will have a direct effect upon this filthiest of all stagnant pools. The canal route would produce no natural current through it unless supplemented with an inlet channel from the lake connecting with the South Fork through which a flow of water can be established. In lieu of this, resort must be had to intercepting sewers and a flushing conduit with pumping works.

To do the work thoroughly a circular conduit 12 feet in diameter would be required, the conduit and intercepting sewers being located as shown on the accompanying map. The intercepting sewers would collect all the sewage south of Thirty-ninth street, including everything from the stock yards and slaughterhouses, discharging directly into the conduit. In addition to the sewage the capacity of the conduit would be such as to provide for a change of water in the South Fork once every twenty-four hours.

In the Appendix is an estimate of the cost of such works with the cost of operation capitalized, which, including the latter, amounts to $646,280.

To meet the local sanitary requirements of the North Branch, the method now in use of flushing it by mechanical means will doubtless have to be continued, but in the near future this must be done on a much larger scale by means of an open channel or its equivalent, located farther north than Fullerton avenue.

The volume of water which must be passed through the South Branch, for the proper dilution of the sewage in the Branch itself, is an important element in this inquiry. To determine this some idea must be had of the population whose sewage is and will be, directly or indirectly, tributary to it.

The population whose sewage was, in 1890, tributary to the various branches of the river and that which is estimated will be tributary to it in about twenty years,

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when the city shall have reached a population of 3,000,000 and the sewage draining into the lake shall have been turned to the river, are as follows:

	1890.	Population, 3,000,000.
North Branch	345,000	1,000,000
Main river	87,000	700,000
South Branch to Bridgeport	277,000	
West Fork	152,500	500,000
South Fork	145,000	700,000
Lake Michigan	151,000	.....
Not sewered	46,500	100,000
Total	1,204,000	3,000,000

It is of course impossible to predict with assurance at what points in the river the greatest contamination will occur from sources other than that of population, though from present indications it is safe to assume that the stock yards and packing industries will remain where they are, so far as they may not be transferred to Stickney; and this, as is well known, is the one great source of river pollution. From these facts it appears that 300,000 cubic feet per minute, or thereabouts, will be needed for dilution in the South Branch of the river, with even a less relative dilution than that specified in the sanitary district law.

CAPACITY OF THE CHICAGO RIVER.

The best guide to the amount of water which it is possible to draw through the Chicago River and its branches, either in its present condition or with modifications, is afforded by gauging of the river made during the late flood from May 6 to May 8, 1892, and similar ones made by the Drainage and Water Supply Commission of Chicago in February, 1887. From these measurements it was found that the maximum discharge through the South Branch was, at 5 p. m. May 6, 1892, 420,000 cubic feet per minute, and on February 10, 1887, 422,000 cubic feet per minute, the former measured near Eighteenth street and the latter at Kedzie avenue.

The maximum discharge through the North Branch occurred May 5, 1892, and from 10 to 12 p. m., and probably amounted to 200,000 cubic feet per minute. The discharge, at the time measurement was made, 11:30 a. m. of the 6th, was 184,000 cubic feet per minute. For the 1887 flood the maximum was 125,000 cubic feet per minute on Feburary 10, the former measured at Clybourn place and the latter at Bowmanville.

The maximum discharge from the main river was, approximately, as follows (some allowance being made for water that reached the river below the point of measurement): On May 6, 1892, 584,000 cubic feet per minute and on Feburary 10, 1887, 560,000 cubic feet per minute.

To pass 300,000 cubic feet per minute through the South Branch with the conditions existing on May 6, 1892, required a fall for different reaches as follows:

Reach.	Distance.	Total fall.	Slope per 1,000 feet.
	Feet.	*Feet.*	*Feet.*
Bridgeport to Sixteenth street	9,200	1.04	0.113
Sixteenth street to Harrison street	5,600	0.53	0.095
Harrison street to Lake street	4,200	0.98	0.233
Bridgeport to Lake street	19,000	2.55	0.134

The velocities which obtained at various places on the South Branch on May 6, at maximum flood, when 420,000 cubic feet of water per minute was flowing, ranged from 2.44 feet per second in the wider sections of the river to 5.18 feet per second opposite the cofferdam of the West Division Street Railway Company near to Van Buren street; and for 300,000 cubic feet discharge per minute the velocities at the same places were 1.96 and 3.91 feet per second respectively.

The maximum discharge through the main river was, as above given, approximately 584,000 cubic feet per minute, and occurred on May 6 from 11:30 a. m. to 5 p. m., during which time the average total fall from Lake street to the mouth, a distance of 7,200 feet, was 1.02 feet, or 0.141 per 1,000.

From these observations and other information, I conclude that to preserve safe

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and easy navigation of the Chicago River the velocity should not exceed 1½ miles per hour, or 2.2 feet per second.

To get 300,000 cubic feet per minute through the South Branch of the river with this limit of velocity will require material changes. North of Sixteenth street, except at bridges, it can be accomplished by deepening the river to 17 feet in the narrowest places and to a less depth in the wider places. At all bridges, except at Adams, Jackson, and Polk streets, and at the Wisconsin Central Railroad bridge, it can be accomplished by deepening to 18 feet. At Adams and Jackson streets it can be done by opening new passages for water west of the center piers. At Polk Street and the Wisconsin Central Railroad new bridges will be required, or some radical modifications giving an increase in the water passages. South of Sixteenth street it will be necessary to resort to a more general widening, deepening, and redocking of the river on one side and the building of new bridges.

In the event of the adoption of the South Fork and Canal route this general widening must be carried to Thirty-fifth street and the deepening made clear through to the entrance to the main channel.

To pass 600,000 cubic feet per minute through the river all the bridges would have to be rebuilt or additional passages provided around their abutments, the main river deepened and perhaps widened in places, and the South Branch throughout radically widened and deepened. Such an undertaking would be formidable and can only be justified as a last resort or on the grounds of a necessary harbor improvement after every other available means of securing such an improvement shall have been shown to be impracticable and unattainable.

ADDITIONAL SUPPLY OF WATER.

The question of securing an inlet for an additional 300,000 cubic feet of water per minute may be considered wholly with reference to sanitary requirements, all collateral benefits and advantages in this way of improved navigation, enlarged harbor facilities, and the possible relief from the downtown bridge nuisance being ignored; or all of these things may be taken into account and that solution of the problem predicted which will most inure to the general good, not only of Chicago in its dual corporate capacities as city and sanitary district, but to the people of the State and the United States.

While it may not be the province of the sanitary district, strictly speaking, to make any provisions for navigation other than that rendered obligatory by law, or to provide harbor facilities for the city of Chicago, it does seem not only within its province, but at least morally binding upon it, so long as these problems are pressing for a solution and all matters pretaining thereto are in a formative stage, to shape the work in hand as to render coöperation between it and other governmental agencies possible in carrying out supplemental works, as only by such coöperation is it possible to secure the best sanitary, financial, and constructive results. Working upon this theory I shall discuss the questions of supplemental channels and inlets in their relation to the two routes under consideration for the main channel, from two standpoints: (*a*) Strictly from the narrowest sanitary point of view, confined to the sanitary district as such. (*b*) With reference to the broadest sanitary, commercial, and political interest of this community and of the country at large.

(*a*) But for the southern boundary of the sanitary district being Eighty-seventh street, thus placing limitations upon the sanitary problem of the city, it would be obligatory to consider a supplemental channel entering the South Fork from the mouth of the Calumet River, which would intercept the sewage that finds its way into the lake from that source, such channel being made to furnish the additional supply of water and to provide main drainage for that part of the city comprising the old town of Lake and the southern part of Hyde Park. But omitting this, because of the omission of the southern part of the city from the sanitary district, we have to consider under this head only the cheapest possible way of obtaining 600,000 cubic feet of water per minute from the lake and the best location of the main channel west of Ashland avenue to adapt it to the lake inlet.

As has already been pointed out, provisions for obtaining 300,000 cubic feet per minute through the South Branch north of Sixteenth street can be made at a comparatively small expense. Another 300,000 cubic feet per minute can be obtained by gravity through a covered conduit laid from the lake to the river along Sixteenth street. Such a conduit, including intake, would be about 4,000 feet long and would need a cross section of about 1,250 square feet. It could probably best be constructed as a twin conduit. To permit of its construction it would be necessary to condemn a strip of property 50 feet wide along the south line of Sixteenth street, which property, after the construction of the conduit, would be as valuable for building sites as now.

The South Branch, south of Sixteenth street, would have to be improved to a

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capacity of 600,000 cubic feet per minute, which it can be made to carry with but little more expense than is needed for 300,000 cubic feet per minute, since radical widening, deepening, redocking and rebridging will be necessary in either case. Though I am not prepared to give the cost of such work, rough estimates have been made which establishes this beyond all question as the cheapest way in which the main drainage canal can be supplied with the amount of water which will ultimately be required. In the event of the adoption of this plan the "canal route," viewed from the standpoint of supplemental works alone, will be the cheapest, since the cost of the intercepting system and flushing conduit for the South Fork with the expense of operation capitalized, viz, $646,280, is much less than the cost of improving the South Fork to carry 600,000 cubic feet per minute, which would have to be done under this plan if the main channel started from the South Fork.

(*b*) If, as proposed under this subhead, we consider the matter of supplemental works, with reference to subsidiary questions which it is next to impossible to divorce from the main question of sanitation, the scope of the inquiry is much broadened. The three principal considerations justifying this are as follows:

The city of Chicago is confronted with the commercial situation of having at low water a harbor that will barely admit vessels drawing 14 feet of water. The present harbor is too narrow, too shallow, and too tortuous to admit the class of vessels which are fast taking to themselves the carrying trade of the lakes. Vessels nearly 350 feet long and that now carry from 2,000 to 3,000 tons, with present harbor facilities and depths of channels at the St. Clair River Canal and the Lime Kilns, would be loaded to 18 to 20 feet draft and carry from 3,000 to 5,000 tons if sufficient depth was available. The shallow places throughout the lakes and the Sault Ste Marie Canal are being improved and deepened by the United States Government to 21 feet. When this work is completed, which will be done in a few years, Chicago's commercial interests will be seriously threatened if a more adequate harbor is not provided. Already cheaper lake freight rates prevail between Duluth and Buffalo on both grain and coal than between Chicago and Buffalo, notwithstanding 111 miles greater distance to Duluth and the necessity of passing the Sault Lock.

Again, the United States Government is committed to improved navigation of the Illinois River, by reason of the money already expended thereon, and that which is about being expended upon the Hennepin Canal. The sanitary district channel will, inevitably, be the most important link in this chain of waterways, and Government interests will demand a suitable lake connection.

The third consideration is found in the urgent need of relieving street traffic in the central part of the city from the incubus of movable bridges. The injury that such bridges are to business interests is beyond computation and too evident to need more than a mention here.

Believing, as I do, that these considerations will, by the time the main channel is completed from Ashland avenue to Joliet, force the recognition of the necessity of new harbor entrances, it is impossible to consider as final any plan for a new inlet from the lake to the river except one that will answer the three-fold purpose of sanitarian, a harbor entrance, and an outlet for what I believe will become a great inland waterway. Hence we have to inquire which of the two routes under consideration is best calculated to fit any possible location for such a channel. If the channel from the lake should connect with the South Branch north of Bridgeport, or should the river itself be deepened and widened throughout so as to give ample capacity for all purposes, then the "canal route" will obviously be the best that can be chosen.

On the other hand, should the new channel enter the South Fork at its southern extremity, then the "canal route" would not connect so directly with the lake as the "South Fork and canal route," but it would cost no more to pass the water northward than southward through the South Fork to the main channel, and in either case the intercepting system and flushing conduit would be dispensed with.

It should be said that, on the theory herein advanced, the Chicago Harbor will become the terminus of lake commerce on the one hand, and of river and inland commerce on the other, and not a mere short cut for vessels passing from the lakes to the river and *vice versa;* hence the matter of a more or less direct connection between the main drainage channel and the lake is, as it seems to me, of but little consequence, provided the connecting channel is so made as to give free and unobstructed navigation for the largest lake vessels.

Free movement is far more important than a shortening of the distance in the Chicago Harbor. Indeed every local interest which will be dependent upon water transportation, directly or indirectly, will only be benefited by a commodious harbor many miles in length lying within the limits of the city. In other words, the Chicago Harbor should be looked upon primarily as the terminus for marine commerce from both the lakes and the river, and not in the light of a through-passage channel. The difference in the character of vessels which will seek this port from the different directions decrees that such shall be the case.

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My conclusion then is that there is but little choice between the two routes for the main drainage channel west of Ashland avenue, as far as any possible connection with Lake Michigan is concerned, and as every other consideration points to the "canal route" as the preferable one, I believe there can be no doubt about the advisability of adopting it.

The reasons for this conclusion may be briefly recapitulated as follows:

(1) On a like basis as to right of way it is shown to be $1,058,901 cheaper than the next cheapest route, and by sacrificing certain prospective advantages in the way of dockage it may be made $1,963,901 cheaper than the next cheapest possible route.

(2) Work can be begun on it immediately, quite likely saving a full year in time.

(3) With the changes proposed it is open to less objection from a railroad standpoint than any other route.

(4) Should supplemental works to supply water to the main channel be carried out in accordance with the narrowest requirements, it is located in the best position to command the situation. On the other hand, should they be projected on the broadest lines, it still meets the situation as fully as any other location.

FLOOD WATERS.

In order that the estimates for the main channel between Ashland avenue and Willow Springs may cover all collateral works, it is necessary to deal with the flood-water question and its relation to the main channel. This involves a consideration of (1) the sanitary question of Chicago as affected by floods; (2) the disposition of the Des Plaines and Chicago rivers flood waters.

(1) The protection of Chicago's water supply from sewage pollution is by far the most important phase of the sanitary question. The greater or less dilution of the sewage, so long as it is confined to the Chicago River or to the main drainage canal, is to the people of this city of little moment compared to the importance of keeping sewage, even in small quantities out of the lake. The reasons for this are too palpable, too well known and acknowledged to need stating here. Hence, from the inception of the project for the sanitation of the city via the Des Plaines and Illinois rivers until now, every fair mind that has intelligently approached the subject has recognized that the prevention of all flood-water discharge from the Chicago River into the lake is a *sine qua non* of the plan.

(2) Owing to the relations which the upper Des Plaines River, when in flood, sustains to the Chicago River, and the occupancy of the lower Des Plaines River Valley with the main drainage canal, the plans of the Chicago Drainage and Water Supply Commission provided that the flood water from 440 square miles of the Des Plaines Valley and from 120 square miles of the North Branch of the Chicago River was to be turned to Lake Michigan through cut-off channels uncontaminated with sewage, thereby reducing the flood volume from the combined catchment basins of the two rivers, of which 400 square miles would remain, to such proportions that a channel of the capacity proposed, viz, 600,000 cubic feet per minute, would prevent an outflow from the Chicago River into the lake. By such an arrangement the Des Plaines River could be taken into the main drainage channel at Summit with impunity.

This method was then, in the absence of much knowledge which has since been gained of the Des Plaines and Illinois rivers, apparently the best and safest for accomplishing the end in view.

The further study which has been given to the subject in connection with the detail location of the main drainage channel has convinced me that a cheaper and perhaps equally safe method is to call into service the combined capacity of the Des Plaines River and the main drainage channel beyond Summit to carry off the floods of the Des Plaines and Chicago rivers.

During the late flood of May 6 there was a maximum of 606,000 cubic feet per minute passed through the Des Plaines River below Riverside, and on February 10, 1887, a maximum of 620,000 cubic feet per minute. On April 21, 1881, the water at the place where these measurements were made reached 1.4 feet greater height, which indicated a discharge of 810,000 cubic feet per minute. Of this amount at least one-third, and perhaps a greater proportion, passed down the Des Plaines River below Summit. By the removal of a few obstructions, and a little forcing by raising the height of floods slightly at Summit, there seems no reason to doubt that the Des Plaines River itself can be made to carry 400,000 cubic feet per minute from Summit down, leaving about the same quantity to be taken into the main drainage channel at Summit. If this can be done without setting the water toward the lake at any point in the Chicago River, then the flood waters will have been provided for so far as furnishing a channel for them across the divide is concerned.

The watershed of the North Branch of the Chicago River comprises 172 square miles, and other portions of the river, including the South Fork, the West Fork,

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and Ogden Ditch to Summit, 109 square miles. The maximum discharge of the North Branch during the May flood was about 200,000 cubic feet per minute, this flow occurring at least twenty hours after the storm. Many hours before the North Branch had reached its highest the maximum flow from the sewered part of the city, and of the other branches of the Chicago River had come and gone, so that we may feel safe in assuming that 300,000 cubic feet per minute is the greatest amount of storm water which will need to pass through the main drainage channel between Chicago and Summit to prevent an outflow to the lake, provided the Des Plaines River floods are kept out of the West Fork. To carry this amount to Summit through the full-sized channel as projected—200,000 cubic feet coming from the North Branch and 100,000 from other branches of the river and other parts of the district—will require much less fall than the normal flow, thus allowing the flow line of the main channel from Summit to be raised and the capacity of the channel at low-lake level increased to 730,000 cubic feet per minute, which is more than equal to the flood waters of the Chicago River—300,000 cubic feet plus 400,000 cubic feet, the surplus flood waters of the Des Plaines River. The combined capacity of the Des Plaines River and the main drainage channel when in flood, with the lake at mean height, will be upwards of 1,200,000 cubic feet per minute.

I am not prepared to say, finally, that it will be permissible to turn such an amount of water into the Des Plaines River below Joliet, a more extended investigation and thorough study of the problem being first necessary. The following facts and considerations, however, seem to indicate the practicability of such a thing.

During the May flood, which was unusually heavy along the river above Joliet, there passed through Joliet approximately 625,000 cubic feet per minute; this extreme occurred, however, more than twenty-four hours before the Upper Des Plaines reached its maximum. At Morris the maximum discharge of the Illinois River, as ascertained by gaugings made by the Engineering Department on May 6, was 4,416,000 cubic feet per minute, and it occurred the same day that the Upper Des Plaines at Summit was at its highest, showing that at this place the maximun was due to other sources of supply than the Upper Des Plaines. From Lasalle to the mouth, the river at flood times spreads out to such wide proportions that the maximum discharge at Grafton was not attained until about May 23, seventeen days later than at Morris. Owing to the equalizing tendency which these facts exhibit as the regimen of the Illinois River, it seems evident that the floods from the Des Plaines River above Summit are not likely to affect extreme floods in the Illinois River other than by prolonging them; the additional amount of water which may be added by the main drainage channel and the upper Des Plaines in the manner described having but little if any effect. Hence, I believe it may safely be said that whatever damage is done in the Illinois Valley by water discharged from the sanitary district channel will occur at intermediate stages with nothing more than the normal flow of the drainage channel combined with medium floods in the Illinois River. But even if the extreme floods of the Illinois River should be slightly increased, it should be remembered that, after land has been overflowed, to add a few inches more or less to the superincumbent water would do no harm; it is the first flood that does the damage. Another consideration is that the modifications of the river that will be necessary to care for the normal flow of the drainage channel will be sufficient to prevent any increase of extreme flood heights, even with the floods of the Upper Des Plaines added. That is, in providing for mean and frequently recurring conditions the maximum and infrequently recurring conditions will be amply met.

Though it is still an open question, I think the probabilities are all in favor of the plan proposed being equally safe and cheaper than any northern diversion as a means of preventing a flow of the Chicago River to the lake, the money which such a diversion would cost being better applied in down-river improvements and modifications. It can also be much more expeditiously put into operation. By the time of the completion of the main drainage channel conditions may have been created, in the manner proposed, that will effectually put a stop to the contamination of Lake Michigan through the Chicago River.

But whatever subsequent investigations may show relative to this matter, there is no doubt about the desirability of taking part of the flood waters of the Des Plaines River into the main channel at Summit, hence the costs of works and right of way necessary to do this is included in the estimates.

Respectfully submitted.

BENEZETTE WILLIAMS,
Chief Engineer.

The honorable the BOARD OF TRUSTEES OF THE
SANITARY DISTRICT OF CHICAGO.

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Appendix.—Estimates Ogden Ditch, Line No. 1.

Capacity, 600,000 cubic feet per minute:		
16,024,000 cubic yards earth, at 18 cents	$2,884,320	
7,620,000 cubic yards glacial drift, at 27 cents	2,057,400	
200,000 cubic yards rock, at $1.25	250,000	
		$5,191,720
Bridges and railroad changes:		
One four-track, South Branch, Union Stock Yards and Transit Company, Chicago, and Northern Pacific, Pittsburg, Chicago and St. Louis Railway	177,000	
One two-track, South Branch, Union Stock Yards and Transit Company, Chicago and Northern Pacific, Pittsburg, Chicago and St. Louis Railway	109,000	
One single-track, Southern Branch, Chicago, Santa Fe and California Railway	66,000	
One double-track, Southern Branch, Chicago, Milwaukee and Northern Railway	146,000	
One double-track, Southern Branch, Chicago and Western Indiana Belt	122,000	
One double-track, Southern Branch, Chicago, Santa Fe and California Railway	105,000	
One double-track, Southern Branch, Chicago and California Terminal Railway	105,000	
		830,000
Four highway swing bridges		180,000
Overflow dam at Summit		40,000
2½ per cent on construction		156,043
Cost of right of way		5,702,000
Total		12,099,763
Capacity, 300,000 cubic feet per minute:		
10,232,000 cubic yards earth, at 18 cents	1,841,760	
4,852,000 cubic yards glacial drift at 27 cents	1,310,040	
200,000 cubic yards rock, at $1.25	250,000	
		3,401,800

J J 5.

OPERATING AND CARE OF LA GRANGE LOCK AND DAM, ILLINOIS RIVER, ILLINOIS.

Under the indefinite appropriation for "operating and care of canals and other works of navigation," as provided by section 4 of the river and harbor act of July 5, 1884, the La Grange Lock has been operated and kept in repair during the past fiscal year.

Lockages for all craft not navigated or propelled by steam have been omitted from the reports. Consequently the lockages for the past year, 218 in number, show a large decrease.

The tonnage, however, of vessels passing the lock was tripled during the year, showing a notable increase in size of vessels.

During the year minor repairs were made to lock gates and machinery as needed; an ice-breaker constructed above the lock; 212 linear feet of revetment or guide wall were constructed along the land above the entrance to the lock, and all buildings and wood and iron work about the lock kept well painted.

The lock force, when not engaged in operating the lock, were kept at work in constructing the revetments, grading and improving the grounds, and repairing, painting, etc., the appointments of the lock.

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The amount expended during the year was $8,004.06, a detailed statement of which, in accordance with the act of July 5, 1884, is herewith.

A report by Assistant Engineer C. V. Brainard, hereto attached, gives a detailed account of all work done at this lock during the year ending June 30, 1892.

Expended during the fiscal year ending June 30, 1892, from the indefinite appropriation for "operating and care of canals and other works of navigation," in operating and keeping in repair the La Grange Lock on the Illinois River.

Services of lock-tenders and watchmen		$3,929.93
Services of crews of dredge and tender		567.17
Fuel for dredge and tender		267.75
Subsistence—		
Labor		239.72
Stores		35.20
Oil and supplies for lighting lock		25.84
Repairs to pump dredge		270.34
Miscellaneous repairs to plant—		
Labor		13.50
Materials		36.61
Tools		92.48
Centrifugal pump		755.00
Kitchen outfit for dredge		14.90
Iron, paint, etc., for repairs to lock gates		201.62
Supplies for lock pumps		23.90
Building pile revetments above and below lock:		
Labor	$429.14	
Materials	118.59	
		547.73
Lumber, rubblestone, piles, and drift bolts for building ice crib		736.76
Harvesting ice, labor		135.35
Rent of telephone		31.25
Traveling expenses		64.68
Freight and express charges		14.33
Total		8,004.06

Money statement.

July 1, 1891, balance unexpended (reported outstanding June 30, 1891)	$834.47
July 29, 1891, allotment	10,000.00
	10,834.47
June 30, 1892, amount expended during fiscal year	8,004.06
July 1, 1892, balance unexpened	2,830.41
July 1, 1892, outstanding liabilities	238.00
July 1, 1892, balance available	2,592.41

REPORT OF MR. C. V. BRAINARD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Kampsville, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit report for the operating and care of Lagrange Lock, Illinois River, for the year ending June 30, 1892.

During the year 218 lockages were made, exclusive of boats on this work and skiffs. During the high water the past spring 81 steamboats passed over the dam, which, added to the number of lockages, makes 299. This shows a decrease of 91 as compared with the same class of boats last year. This is due to the extreme low water of September, October, and November, during which time the mean stage of water was 0.25 feet as against 1.50 feet above low water in 1890 during the same months.

The river was closed by ice during the month of January. During the months of December, January, and February, except for a few days in January, the lock force

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was reduced to the overseer and two watchmen. About 300 tons of ice was put up by the lock force.

A scoop shovel was rigged with a long handle and mounted on a pair of shears for removing the deposit from the gate recesses. About 9 cubic yards were removed in this way.

Thirty-five piles, to be driven as guide piles below the land wall, were cut and floated to the lock by the lock force during the high water in May. When not engaged in operating the lock the force has worked on the revetments above the lock, the ice-protection crib, and keeping the dam cleared of drift.

Repairs.—A new nosing was put on the upper gate. The decking on the lower gates was renewed and calked. Fifteen long anchor rods were put in the revetment below the lock. The valves of the upper gates not working properly, they were examined by a diver, and by removing some shims below the pinions, the pinions and segmental gear were made to mesh properly.

A revetment 212 feet long was built above the land wall of the lock, containing 76 piles, of which 23 are anchor piles, 204 Wakefield sheet piles, 26 tie rods, 440 lineal feet of 6 by 12 inch oak wales, and 220 lineal feet of 10 by 10 inch pine wales. The angle where the revetment joins the return wall of the lock was filled with concrete.

An ice-protection crib was built above the river wall, the top being 14 feet above low-water surface above the dam and on a level with the top of the lock walls; 28 piles, 144 linear feet of 4 by 8 inches oak wales, 6,000 feet B. M. 3 by 12 inches pine lumber for sheet piles, 5,840 feet B. M. 10 by 10 inches pine lumber, 6,800 feet 10 by 12 inches pine lumber, 40 ¾ by 18 inch drift bolts, 400 ¾ by 16 inches drift bolts and 110 cubic yards of rock filling were used.

Dredging.—The last of August, Dredge No. 1, steamer *Enterprise*, and three dump-scows were taken to La Grange Lock to dredge the entrances to the lock. The depth dredged in the lower entrance was 5.4 feet and in the upper entrance 6.3 feet. One day was spent in casting back of the revetment below the lock and three days casting back of the revetment above the lock.

Twelve thousand five hundred and eighteen cubic yards of material were removed from the entrances, 190 cubic yards of it being from above the lock and the remainder from below the lock. Seven hundred and fifty-seven cubic yards of this material was handled a second time in putting it back of the revetment above the lock. The remainder was dumped on the east side of the river below the dam. October 18 dredging was discontinued and the fleet laid up. Steamer *Enterprise* started for Kampsville Lock, but grounding at Meredosia, lay there in charge of a watchman until the river rose sufficiently to float her, when she was taken back to La Grange Lock. December 9 she and three dump-scows were taken to Kampsville Lock.

The following work remains to be done: Build permanent quarters for lock-keepers; place 9,300 cubic yards of filling around the superintendent's house; 2,500 cubic yards of stone to be placed below the dam, and drive a row of guide-piles below the land wall.

Very respectfully, your obedient servant,

C. V. BRAINARD,
Assistant Engineer.

Lockages made at La Grange Lock, 1891–'92.

Class.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Feb.	Mar.	Apr.	May.	June.	Total.
Steam vessels	37	33	26	7	9	.....	5	30	24	2	1	174
Barges	18	10	6	5	5	.....	.....	25	40	5	.....	114
Sailing vessels	.....	.....	1	1	3	.....	.....	.....	.....	.....	.....	5
Cabin boats	.....	.....	.....	.....	.....	4	3	5	.....	.....	.....	12
Total	55	43	33	13	17	4	8	60	64	7	1	305

The following boats passed over the dam during high water.

Month.	Steamboats.	Barges.	Total.
April	17	9	26
May	30	24	54
June	44	20	64
Total	91	53	144

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Tonnage passing La Grange Lock during the year ending June 30, 1892.

Class.	Passed through the lock.				Passed over the dam.		
	Registered tonnage.	Freight.	Passengers.	Stock.	Registered tonnage.	Freight.	Passengers.
		Tons.		*Head.*		*Tons.*	
Steamboats	37,585.91	2,144	973	219	23,973.29	14	355
Barges	47,430.00	33,455	.....	.....	29,681.00	6,900	.....
Total	85,015.91	35,599	973	219	53,654.29	6,914	355

List of steam vessels passing La Grange Lock 1891–'92.

Name.	Registered tonnage.	Name.	Registered tonnage.	Name.	Registered tonnage.
D. H. Pike	466.75	H. W. Longfellow	40.00	Polar Wave	150.00
Dispatch	5.00	Rackett	57.80	D. M. Schmoldt	13.00
Fearless	77.16	New Idea	176.00	Joliet	75.00
City of Pekin	10.00	Dick Clyde	76.00	Josie	237.51
Lotus	20.00	Verona	10.00	Grey Eagle	
Lily (U. S.)	300.00	Borealis Rex	116.13	City of Peoria	128.00
Belle of Ottawa	10.00	Magnet	42.30	White Eagle	312.75
Frankie Folsom	35.00	City of Brunswick	77.01	Rescue	139.30
City of Florence	358.00	Ida Morse	10.29		

J J 6.

ILLINOIS AND MISSISSIPPI CANAL.

The object of this improvement is to furnish a navigable waterway from Lake Michigan to the Mississippi River at the mouth of Rock River in connection with the upper Illinois River, and the proposed enlarged waterway along the present line of the Illinois and Michigan Canal.

The river and harbor act of September 19, 1890, contained the first appropriation for beginning the construction of this canal.

With reference to this work it is to be said that various surveys of different routes from the great bend of the Illinois River to the Mississippi River at or above the mouth of Rock River have been made: In 1871, G. P. Low (Report Chief of Engineers, 1871, page 303); in 1882, Major Benyaurd (Report Chief of Engineers, 1883, page 1757), and in 1885, Major Handbury (Report Chief of Engineers, 1886, page 1707).

There was also a report upon this canal by a Board of Engineers in 1887 under the provisions of the river and harbor act of August, 1886 (Report Chief of Engineers, 1887, page 2125). All of the local engineers and the Board of Engineers of 1887, for engineering reasons, have preferred and recommeded the Marais d'Osier route, but for commercial reasons the Chiefs of Engineers, Generals Newton and Duane, and the Secretaries of War preferred the Rock Island route, and that route has been finally adopted.

Detailed plans and estimates based entirely upon preliminary surveys, under the act of August 11, 1888, were prepared and submitted to Congress June 21, 1890, the report of which location, plans, and estimates (without maps and drawings) were submitted June 21, 1890, and published as House Ex. Doc. No. 316, Fifty-first Congress, first session.

This report was the basis evidently of subsequent appropriations.

Under the requirements of the act of September 19, 1890, it was recommended by this office and approved by the Chief of Engineers, that for reasons given in the report of the Chief of Engineers, 1891, page 2634, that work upon this improvement should begin at the mouth of Rock River, and that the appropriation be expended at that point.

After examination, a route was recommended along the south bank of Rock River, near its mouth, around the lower rapids of Rock River, embracing 5 miles, more or less, of the canal, and for reasons given in the Report of the Chief of Engineers for 1891, this location was approved by the Secretary of War March 25, 1891. Accordingly legal descriptions of all lands required for this section of the canal were prepared, and the matter of obtaining titles to the necessary rights of way placed in the hands of the Department of Justice, and referred by the Attorney-General to the district attorney for the northern district of Illinois.

Later the approved route was opposed and resisted by interests centering at Rock Island, Ill., and the question of the location of the western terminus of the Illinois and Mississippi Canal, narrowed by the provisions of the act of September 19, 1890, to the question of (1) what constituted the mouth of Rock River and (2) whether the northerly or southerly bank of Rock River should be followed, was reopened and a Board of Engineers convened by direction of the Secretary of War by Specials Orders, No. 48, Headquarters Corps of Engineers, dated August 18, 1891.

The report of this Board, which was formally approved by the Secretary of War, is hereto attached, and in accordance with its recommendations, the route approved by the Secretary of War March 25, 1891, was finally fixed and adopted.

The condemnation cases in obtaining rights of way came up in the United States district court for the northern district of Illinois, southern division, at its October term, at Peoria, Ill., and awards made in all cases, except in the case of the parcel of land required for the crossing of the tracks and embankment on the head of Big Island of the Rock Island and Peoria Railroad, which involved a contest. The awards of the court were, after examination, approved by the Department of Justice March 8, 1892, which approval with directions to pay the awards were received at this office April 21, 1892.

The necessary funds for the purpose were applied for and paid over, and the work as far as justified by the titles secured, *i. e.*, for some 3 miles or less of the canal trunk, and three lock pits and foundations, was advertised under date May 25, 1892, the proposals to be opened June 25, 1892. Proposals were accordingly received and opened, an abstract of which proposals is hereto attached. Very advantageous terms and prices were offered.

Awards were recommended to be made to the lowest responsible bidder on each piece of work advertised, but up to the close of the fiscal year ending June 30, 1892, awards had not been made.

With reference to the crossing of the Rock Island and Peoria Railraod tracks and embankment, a contest was before the court and the case was continued. Afterward, during the recess of the court an agreement between the railroad company and the officer in charge, subject to approval by the Secretary of War, was arrived at, which agreement was believed to be based upon—

First. The decree of the United States district court, northern district of Illinois, in the case of condemnation of a right of way across the tracks of the Rock Island and Milan highway and street railroad, afterwards approved, which required the construction and maintenance of a bridge by the United States.

Second. Upon the decisions in like cases of the supreme court of the State of Illinois, the laws of which State as far as applicable to the case had been adopted by the United States by river and harbor act approved September 19, 1890.

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(3) Upon the enumeration, among works of navigation required for this canal by the act of September 19, 1890, of "bridges" to be constructed, it was inferred by the United States.

(4) Upon the provisions of the river and harbor act of July 5, 1884, section 4, making an indefinite appropriation for the "operation and care of canals and other works of navigation."

After a protracted investigation the Secretary of War decided that under the laws of the United States he was not authorized to enter into such an agreement, and directed that the lands of this railroad company be condemned for the purposes of the canal.

Afterwards on application by the district attorney for the northern district of Illinois that the basis of condemnation be specified, *i. e.*, that the character of bridge to be constructed by the railroad company, whether fixed or swing, as well as other description, be indicated, it was answered by the Secretary of War in effect that the general laws relating to bridges in the river and harbor act of September 19, 1890, and former acts, applied in this case and that he was not authorized by law to indicate what bridge would be permitted to be constructed and maintained over the canal by the railroad company.

The matter again came up before the United States district court at its spring term, 1892, but as no basis of condemnation of a right of way across the public highway, except an unconditional crossing by a canal 80 feet wide at the water surface, and 7 feet deep, or 14 feet below the level of the tracks of the railroad, could be presented under the ruling of the Secretary of War by the United States, the court continued the case, and intimated that until the United States officers could specify a basis of joint user over the joint crossing that the case would be indefinitely continued, or that the jury would be instructed to assess the award for the land and damages at the full value of the Rock Island and Peoria Railroad, less the proved value of their lands and property for other purposes than as a public carrier between Rock Island and Peoria. The case thus stood at the close of the fiscal year.

The river and harbor bill pending at the close of the fiscal year ending June 30, 1892, contains a provision that specifically defines the basis of agreement or condemnation in all such cases, and if passed will remove the otherwise insurmountable obstacle to the construction of the canal indicated by the ruling of the Secretary of War and the attitude of the United States district court for the northern district of Illinois, before which court all condemnation suits will be tried.

PROPOSED APPLICATION OF FUNDS ON HAND.

The funds now on hand will be applied to the payment of expenses connected with the legal proceedings in acquiring right of way around the lower rapids of Rock River, near its mouth, and to purchasing the necessary plant, and constructing the works of navigation in the vicinity of said rapids.

PROPOSED APPLICATION OF FUNDS REQUIRED FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

These funds will be applied, if appropriated, to the definite location of the canal on the approved route, to the fixing of landmarks, and to determining legal descriptions of lands required for rights of way; to payments for such lands and towards the construction of the canal trunk and works of navigation along the line as far as may be determined.

In former reports of the Chief of Engineers, already cited, a full description of this canal and of its probable commercial importance are given, and it is not necessary further to repeat them herein.

Money statement.

July 1, 1891, balance unexpended	$489,031.10
June 14, 1892, refunded on account of overpayment	.50
	489,031.60
June 30, 1892, amount expended during fiscal year	25,235.61
July 1, 1892, balance unexpended	463,795.99
July 1, 1892, outstanding liabilities	189.42
July 1, 1892, balance available	463,606.57
Amount appropriated by act approved July 13, 1892	500,000.00
Amount available for fiscal year ending June 30, 1893	963,606.57
Amount (estimated) required for completion of existing project	5,925,960.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	1,500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Statement showing names of lowest bidders, and amount of their bids, for the different sections of work, to accompany abstracts of proposals for constructing 3 miles of canal trunk, etc., Illinois and Mississippi Canal.

Sections of work.	Monroe & Richardson, Portsmouth, Ohio.	Michael H. King, Des Moines, Iowa.	A. J. Whitney, Rock Island, Ill.
Three miles of earthwork, canal trunk	$26,830.51		
Sand and pebble at Lock 37			$1,820.00
Sand and pebble at Lock 36	2,375.00		
Sand and pebble at guard lock	3,050.00		
Lock pit and foundation:			
No. 37			17,618.60
No. 36	12,456.86		
Guard lock		$8,322.52	

Total cost of work $72,473,49.

Abstract of proposals for constructing 3 miles or less of canal trunk, excavating lock pits and constructing foundations for three locks, and screening, sorting, and delivering pebbles and sand, received in response to advertisement dated May 25, 1892, and opened at 12 m. June 25, 1892, by Capt. W. L. Marshall, Corps of Engineers.

No.	Name and address of bidder.	Earthwork for 3 miles.	Sand and pebbles at gravel pit.	Sand and pebbles delivered at—			Sand and pebbles delivered at locks.
				Lock 37.	Lock 36.	Guard Lock.	
1	David Condon, South Omaha, Nebr	$107,584.75	$5,925.00	$5,600.00	$3,400.00	$5,350.00	$14,350.00
2	Michael H. King, Des Moines, Iowa	30,049.65					
4	Builders' Sand and Gravel Company, Davenport, Iowa			4,840.00	4,100.00	6,750.00	15,690.00
5	John Killeen, New Liberty, Iowa	95,856.29	8,220.00	6,500.00	4,375.00	6,250.00	17,125.00
6	Monroe & Richardson, Portsmouth, Ohio	26,830.51	3,055.00		2,375.00	3,050.00	
7	A. J. Whitney, Rock Island, Ill			1,820.00			
8	Wilcoxon, Quigley & Moore, St. Louis, Mo	34,866.17	6,480.00	3,884.00	2,175.00	6,025.00	12,084.00
9	The Heidenreich Company, Chicago, Ill	33,666.60	5,480.00	7,280.00	4,900.00	8,750.00	20,930.00

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LOCK PIT AND FOUNDATION LOCK 37.

No.	Name and address of bidder.	Earthwork.	Material.	Totals.
5	John Killeen, New Liberty, Iowa	$49,392.00	$11,738.00	$61,130.00
7	Andrew J. Whitney, Rock Island, Ill.*	8,643.60	8,975.00	17,618.60
8	Wilcoxon, Quigley & Moore, St. Louis, Mo	14,076.72	10,474.50	24,551.22
9	The Heidenreich Co., Chicago, Ill	22,226.40	14,143.00	36,369.40

* Lowest bidder.

LOCK PIT AND FOUNDATION, LOCK 36.

No.	Name and address of bidder.	Earthwork.	Material.	Totals,
5	John Killeen, New Liberty, Iowa	$4,083.30	$10,845.00	$14,928.30
6	Monroe & Richardson, Portsmouth, Ohio*	2,631.46	9,825.40	12,456.86
8	Wilcoxon, Quigley & Moore, St. Louis, Mo	3,992.56	9,390.10	13,382.66
9	The Heidenreich Co. Chicago, Ill	4,537.00	12,114.90	16,651.90

*Lowest bid.

LOCK PIT AND FOUNDATION, GUARD LOCK.

No.	Name and address of bidder.	Earthwork.	Rock.	Totals.
2	Michael H. King, Des Moines, Iowa*	$3,107.52	$5,215.00	$8,322.52
3	David Sears, Rock Island, Ill	1,434.24	7,748.00	9,182.24
5	John Killeen, New Liberty, Iowa	4,183.20	11,920.00	16,103.20
6	Monroe & Richardson, Portsmouth, Ohio	2,988.00	5,960.00	8,948.00
8	Wilcoxon, Quigley & Moore, St. Louis, Mo	4,661.28	13,410.00	18,071.28
9	The Heidenreich Co., Chicago, Ill	2,988.00	6,705.00	9,693.00

* Lowest bidder.

REPORT OF MR. L. L. WHEELER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Milan, Ill., June 30, 1892.

CAPTAIN: I have the honor to submit the following report upon the work on the Illinois and Mississippi Canal, under my own immediate supervision, for the fiscal year ending June 30, 1892:

At the beginning of the year the force was mainly occupied in preparing plats relating to right of way and in continuing survey of Rock River. Plats of proposed crossing of Rock Island and Peoria Railway were drawn, and general information in regard to ownership of lands compiled for use of United States district attorney. Lists of witnesses were prepared and evidence given in suit for condemnation of lands.

The survey of Rock River was carried up to the mouth of Green River, but above Moline Bridge no topographical work was done on either bank. The notes of the survey between Carrs Island and Moline Bridge were platted, the map completed and traced.

A reconnoissance of the Feeder line was made and an alternative route surveyed for the main line in the vicinity of Wyanet.

Measurements of seven bridges over Rock River were taken and estimates made of cost of raising four of them to give greater clearance at high water.

A series of measurements of the discharge of the several channels of Rock River at low water were made in September, 1891. The method of measurement was by surface and rod floats, the water being too shallow to permit the use of a current meter. Accompanying this report is a table giving the results for the stream as measured above Carrs Island, where all of the water flows in one channel.

An hydrographical survey of the Mississippi River in the vicinity of the mouth of Rock River was made in September, and a map made showing depths at low water.

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A revised estimate was made of amount of earthwork in first 3 miles of canal trunk, and in 3 lock pits. Maps were drawn showing the sites of the work and details. While the river was covered with ice detailed surveys were made of the vicinity of mouth of Mill Creek, where important works will be located, and also of sites of dam abutments. Measurements were taken and an estimate made of the amount of earthwork necessary to raise the grade of the Rock Island and Peoria Railway 3 feet at point of canal crossing.

June 27 the river reached the highest stage ever known. The maximum stage at Guard Lock site, opposite head of Carrs Island, was 135.70, and at mill on Milan front 134.03, or 0.78 foot higher than before known. (See Report of Chief of Engineers for 1891, page 2654.) On June 23, Mill Creek brought down a great flood which surpassed that of June 17, 1891. The necessary field work has been done to give a profile of the flood line and an estimate of the maximum discharge, but the notes are not yet reduced. This flood overtopped the embankment above Milan designed to protect the town from Rock River, flowing over it toward Rock River, and damaged it in several places. Immediate steps were taken to repair the damage, but the flood in Rock River came so soon that the work could not be thoroughly done. A temporary bank was raised on top of the embankment, but the high wind and waves carried this away, and the water came over the embankment for one-half mile in length. The flood from Mill Creek carried out the culvert in the railway embankment and ran over the track for a length of about one-half mile. Before the damage was repaired the flood from Rock River came and has been running over the road for two days. Flood heights in Milan were very materially increased by this embankment, as were also damages by the Mill Creek flood. As it has been proposed to raise this embankment in order better to suit canal levels, careful consideration should be given the matter that the interests of the United States and of the citizens of Milan are properly protected.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

Discharge observations at section about 2,000 feet above Carrs Island.

Date.	Area.	Elevation of water surface.	Width.	Mean depth.	Discharge per second.	Mean velocity per second.	Remarks.
	Sq. feet.		*Feet.*	*Feet.*	*Cu. feet.*	*Feet.*	
Sept. 1, 1891	3,395	126.46	873	3.71	1,950	0.57	Slight wind from southeast.*
Sept. 1, 1891	3,395	126.46	873	3.71	1,837	0.54	Good conditions.
Sept. 4, 1891	3,408	126.31	870	3.56	1,754	0.51	Do.
Sept. 4, 1891	3,408	126.31	870	3.56	1,853	0.54	Very slight wind from east.
Sept. 4, 1891	3,408	126.35	870	3.60	1,671	0.49	Good conditions.
Sept. 7, 1891	3,308	126.35	870	3.60	1,709	0.52	Very slight wind from east.
Sept. 7, 1891	3,308	126.35	870	3.60	1,818	0.55	Do.
Sept. 25, 1891	3,256	126.28	870	3.53	1,487	0.46	Slight wind from northeast.
Sept. 25, 1891	3,256	126.28	870	3.53	1,285	0.39	Slight wind from northwest.

* River here flows due west.

REPORT OF BOARD OF ENGINEERS.

ROCK ISLAND, ILL., *September 12, 1891.*

GENERAL: The Board of Officers of the Corps of Engineers, constituted by Special Orders No. 48, dated Headquarters, Corps of Engineers, August 18, 1891, to consider and report upon the location of the western terminus of the Illinois and Mississippi Canal, assembled at Rock Island, Ill., on Monday, September 7, 1891, and spent the fore-

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noon in conference with a committee representing the Business Men's Association of Rock Island.

In the afternoon the Board met at Milan, Ill., in accordance with the requirement of the order, and also examined on the ground the so-called "Northern route" for the canal. Milan proved to be an inconvenient place for the meetings of the Board; consequently, authority was asked of the office of the Chief of Engineers to hold the subsequent meetings at Rock Island, which was duly granted.

The forenoon of Tuesday, September 8, was devoted to the examination of papers relating to the duties assigned the Board, and to further hearing the committee of the Rock Island Business Men's Association, and the afternoon to an inspection of the depression east of the ridge bordering Pettifers Slough, where it has been proposed to locate a basin for the harbor and accomodation of boats while laid up or while engaged in transferring cargoes. It is also claimed that a basin at this point is a necessary adjunct to the transfer of freight from land to water transportation.

Separate written invitations were extended to the Business Men's Association of the cities of Rock Island, of Davenport, and of Moline, also to Hon. W. H. Gest, J. T. Robinson, esq., and to the Sears Brothers, and, by publication in newspapers, to the public generally, to meet the Board at the rooms of the first-named organization, on Wednesday the 9th, for the purpose of publicly discussing the questions involved.

The entire day of Wednesday was occupied in such discussion; remarks were freely invited and everyone present was not only permitted to express his views but encouraged to do so. Rock Island and Davenport were represented at this public meeting, but, so far as we are informed, Moline took no notice of the invitation.

On Thursday, September 10, the Board proceeded to Milan, Ill., and examined the entire extent of the so-called "Southern route," from its head to its entrance into the Mississippi River at the principal mouth of Rock River.

From this time until the date of adjournment, September 12, 1891, the Board was engaged in considering the matters committed to them, except that on Friday some time was allotted to an interview with the principal owners of property situated along the line of the Northern route who made oral offers as to the prices they would be willing to accept for right of way.

GENERAL DESCRIPTION OF THE LOWER REACH OF ROCK RIVER.

At Milan, about 3 miles from the Mississippi, and just above the foot of the Lower Rapids, Rock River divides into two channels, which enter the Mississippi through separate mouths. The lesser channel, is known as South Slough, and joins the Mississippi about 2 miles below the junction of the principal streams. The low-water discharge of this slough, as measured for the Board on September 4, 1891, is about one-tenth that of Rock River.

Between South Slough and the larger branch of Rock River lies Big Island, several square miles in extent, parts of which are overflowed at high water from a few inches to 10 feet or more in depth. The central portions of this island, however, embrace a very considerable area of well-cultivated ground above high water, and the greater part of the island is used for agricultural purposes.

Below Vandruff Island, the foot of which marks the downstream limit of the rock formation which causes the lower rapids, the main

stream of the river is much obstructed by sand bars. Turkey Island, doubtless one of these bars originally, subdivides this channel into unequal chutes, the lower junction of which lies some 4,000 feet above the confluence of this branch with the Mississippi.

Lying within the angle between the principal branch of Rock River and the main channel of the Mississippi, on the right bank of the former and east or left bank of the latter, lies Pettifer Island, a triangular formation having sides one-half mile or more in length, and a surface which is overflowed at high water. It is separated from the mainland by a narrow channel, 100 feet in width, more or less, through which the direction of flow is variable, depending upon the relative stages of water in the two rivers; flowing in toward the Mississippi whenever Rock River is the higher and in the contrary direction whenever the conditions are reversed.

MOUTH OF ROCK RIVER.

From the foregoing general description it may be said that Rock River enters the Mississippi through three mouths, two of which, however, are insignificant at low stages. These channels form a delta some 3 miles, more or less, in extent, measured along the bank of the Mississippi. It would therefore seem that any proper location of the western terminus of the Illinois and Mississippi Canal, on the Mississippi front of the delta described, would comply with the requirements of the act of September 19, 1890, which directs that the western terminus be "at the mouth of Rock River."

Considering the law in the light of the plans and estimates submitted to Congress under date of June 27, 1890 (House Ex. Doc. No. 429, Fifty-first Congress, first session), and upon which this item in the act of September 19, 1890, was probably based, the Board is of the opinion that only the principal mouth of Rock River was contemplated by the act referred to. In this the Board is sustained by the opinion of Mr. Gest, as expressed at the public hearing. Moreover, the Board is of the opinion that, whether the principal mouth of Rock River was especially contemplated by the act or not, it is the best for the purpose, because it is easier of approach by Mississippi River boats than any other, has as good depth of water as any other, and, at sufficient stages of water, affords a secure harbor (under the lee of Pettifer Island), and that it should therefore be accepted as the mouth prescribed by the law, unless it should appear that commercial conditions require the establishment of the terminus at another point, or should no controlling reason to divert it therefrom become apparent.

INCEPTION OF THE SOUTHERN ROUTE.

The "location, plans, and estimates," prepared under the direction of the Secretary of War, in accordance with the act of August 11, 1888, provided for attaining the terminus by passing around the lower rapids of Rock River by canal and slackwater navigation along the northern shore.

The dams pertaining to this route were indicated at the lower end of Vandruff Island and extended across all arms of Rock River. The canal portion of this route terminated near the foot of Turkey Island; thence to the mouth of Rock River it was proposed to improve the open river by wing dams and resulting scour.

The memoir, or report, accompanying these plans (House Ex. Doc.

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429, Fifty-first Congress, first session, page 4) states with reference to them—

> Early in the progress of the present investigation it was seen that the previous surveys * * * were not in sufficient detail to allow definite and final plans. * * *
>
> When the work is definitely undertaken the vicinity of this line must be further examined, to better, if possible, the location shown upon the maps. * * *

After the passage of the act further examinations were made, as suggested in the report, and the fact was then revealed that the plan, referred to above, for passing the lower rapids of Rock River required modification to the extent that the dams across the south arm of Rock River must be placed at the head of the rapids instead of at the foot, as indicated, and still later it became doubtful if the proposed improvement of the last reach of Rock River would prove successful on account of the apparent small discharge.

Then, still further examination discloses a practicable route upon the south side of Rock River that was thought to possess marked advantages over the improvement as planned along the north bank. This route was therefore recommended by Capt. Marshall, under date of March 19, 1891, and it was formally approved by the Secretary of War March 25, 1891.

As far as known to the Board, the location, plans, and estimates accompanying the executive document above referred to (No. 429) were never formally approved by the Secretary of War, and if that be the case, it may be said that the only part of the Rock Island route for the Illinois and Mississippi Canal (which was designated by him as the one to be followed in preparing plans and estimates under the act of August 11, 1888) that has been definitely located with the formal approval of the Secretary of War is the so-called "Southern route" around the lower rapids of Rock River, terminating "at the mouth of Rock River," as prescribed and directed by the act of September 19, 1890.

With reference to the improvement of the lower rapids of Rock River, it appears that as early as 1867 a canal terminating at the Mississippi River south of South Slough, near the lower end of Rock River Delta, was suggested by Gen. J. H. Wilson in his report on the survey of Rock River. Again, in 1885, when surveys of this locality for the Hennepin Canal were in progress, under the direction of Maj. W. H. H. Benyaurd, Corps of Engineers, under the provisions of the river and harbor act of August 2, 1882, Assistant Engineer G. A. M. Liljencrantz, in a letter dated October 28, 1885, mentioned the fact that the south bank of Rock River was more favorable than the north bank for the construction of the canal in the following language:

> What is the objection to running the canal into Mississippi River south of the mouth of Rock River? * * *
>
> The ground south appears, from indications on the printed maps, to be lower and more favorable than north of Rock River, to which letter Maj. Benyaurd replied under date of October 30, 1885, as follows:
>
> The survey made under direction of Gen. J. H. Wilson, in 1867, demonstrates the feasibility of running a canal to the Mississippi below the mouth of Rock River, but as the law authorizing the present survey requires the canal to terminate on the Mississippi at or above Rock Island, it is not deemed advisable or necessary to consider anything below Rock River.

The suitability of the south shore for the location of this part of the canal, therefore, was recognized before 1890, but the terms of the laws under which the surveys were made, upon which were based the detailed locations, plans, and estimates submitted to Congress, June 27, 1890

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(Ex. Doc. H. R., 429), precluded investigations for this purpose on the south bank of Rock River.

The act of September 19, 1890, fixing the terminus "at the mouth of Rock River," removed this restriction, and allowed any route within the delta of Rock River at its mouth, to be examined by the survey made under Captain Marshall's direction, by Assistant Engineer L. L. Wheeler, and the location along the approved or southern route resulted from the information obtained by this more exhaustive examination.

OBJECTIONS URGED AGAINST SOUTHERN ROUTE.

Since the approval of the location on the south bank of Rock River objections to it on the part of citizens of Rock Island have been presented to the Secretary of War, especially in a communication from the Hon. W. H. Gest, dated August 8, 1891, which communication, with the indorsement of the Acting Secretary of War thereon, has been referred to this Board, and constitutes, together with the order convening the Board, all the instructions received by the Board.

For the proper understanding of the questions at issue, a map* (blue print), with the two lines that have been proposed for carrying the improvement past the lower rapids of Rock River, laid down thereon in colors, is submitted with this report, of which lines following is a condensed description.

NORTHERN LINE AS PROPOSED BY CAPTAIN MARSHALL.

The modified northern line is as follows:

A dam across the South Branch or channel at the head of Carrs Island, the northern channel of Rock River and Sears Canal to be followed; an embankment or levee above high water to be carried continuously on Carrs and Vandruffs Islands to the head of Sears Canal, with a dam (18 feet high) 8.5 feet lift to be built here across the north arm. A lock of 8.5 feet lift with two exits (1), for medium to high and (2) for low-water service, with guard walls 7 feet above low water in the upper pool, to be built at the foot of Sears Canal; thence to the foot of Turkey Island, a canal formed by an embankment in the river bed and a levee on Turkey Island, terminated by a lock of 8.5 feet lift near the foot of Turkey Island; thence to the Mississippi River a little less than a mile, and an improvement by brush wing dams in the bed of Rock River.

SOUTHERN LINE AS PROPOSED BY CAPTAIN MARSHALL.

Dams to be built 7 to 8 feet in height (on rock foundation and of only 4 feet head of water against them) across both channels of Rock River at the head of Carrs Island; the canal thence to the mouth of Rock River to be located on the south bank, either on the main land or on Big Island, with the exception of a section of the canal built by embankment or embankments in the bed of Rock River, from just above the mouth of Mill Creek to the head of Big Island, cutting off and closing the slough behind Big Island; the discharge of Mill Creek to be diverted down South Slough.

Along the route there will be one guard lock at the head of the canal,

* Not printed.

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one lock of 6 feet lift near the head of Silver Lake, and one lock of 12 feet lift directly at the mouth of Rock River.

Along the northern line, as proposed by Capt. Marshall, the harbors and basins were to be in the pool above Sears Canal, and in Turkey Island Chute, above and below the lower lock. Along the southern route, as proposed by Capt. Marshall, basins, as an incident of construction in securing materials for embankments, will be formed above the mouth of Mill Creek, at the head of Big Island, and at Silver Lake.

The harbors will be in the pool in Rock River above Carrs Island, and the Rock and Mississippi Rivers near the lower lock.

The first of the lines described above (except as modified by natural conditions that prohibit dams at Milan of the height required by the original designs) is the same as submitted to Congress by the Secretary of War June 27, 1890 (H. R. Ex. Doc. 429), and the second is the route approved by the Secretary of War March 25, 1891.

The act of Congress of September 19, 1890, appropriating money for commencing the construction of the Illinois and Mississippi Canal, provides for * * * "a canal to connect the Illinois River, near the town of Hennepin, with the Mississippi River at the mouth of Rock River."

The act requires in the canal a depth of 7 feet, and provides for the construction of * * * "guard gates, waste weirs, locks, lock houses, basins, bridges, and all other erections, and fixtures that may be necessary for safe and convenient navigation of said canal."

It appears from the wording of the law and from previous discussions of the subject that the primary object to be attained is the uniting by a practicable water route the navigable waters of the Illinois and Mississippi rivers (as part of a through route of transportation from the Great Lakes to the Mississippi River), furnished with all adjuncts and structures that may be necessary for the proper management, operating and control of the work itself, and for handling the business that may be subserved by the improvement.

The objections urged against the route as approved by the Secretary of War March 25, 1891, and statements in favor of a line along the north bank of Rock River, in the vicinity of its mouth, by the Hon. W. H. Gest, in the document referred to the Board, and by the committee of the Rock Island Business Men's Association, are:

First. The line has been located by Congress along the north bank of Rock River, and can not be changed by the Secretary of War.

Second. That the terminus on the south side is not accessible to railroads, teams, and Mississippi boats, but that a terminus on the north side of Rock River would be easily accessible to the citizens of Rock Island, Moline, and Davenport, and would permit the construction of a basin with constant water level adjacent to the canal, which basin, with adjacent land, would offer facilities for elevators and other appliances for transfer connections between land and water transportations, easily accessible by land. Mr. Gest states that the required facilities, etc., can be found at the terminus on the north bank and at no other point.

With reference to the first objection to the southern line, viz: That Congress has located the canal along the northern bank of Rock River and that the Secretary of War has no authority to change it, this Board considers that as the Secretary of War has exercised such authority in similar instances without number, dating back probably to the foundation of the Government, and moreover, since this is a legal point not referred to the Board by the Secretary of War, it is not within the province of the Board to discuss it, even were they competent to do so;

but granting Mr. Gest to be correct in his argument, the Board considers that a rigid adherence to the northern route as planned and submitted to Congress, would make it impracticable to carry the legal canal depth of water from the foot of Turkey Island to the mouth of Rock River at low stages of water by the means proposed, for the reason that the measured low-water discharge of Rock River, exclusive of South Slough (1,650 feet, more or less) is much less than thought when the plans were made (4,000 cubic feet) (*) and is entirely incapable of performing the mechanical work assigned to it in the original plans. Not only this, but the construction of the dams of the height proposed in the plans submitted to Congress, across the south arm of Rock River at Milan, would cause extensive overflow of Milan and vicinity at every small rise in Rock River, and without works in addition to those proposed in the original plans, for the northern line, the constructions therein proposed could not be maintained, nor on the other hand would a rigid adherence to the plans for the northern line as submitted to Congress June 27, 1890, meet the requirements or desires of the City of Rock Island as argued and expressed by the representative committee of her business men.

The report of Assistant Engineer Wheeler upon the discharge measurements of the present low-water flow of Rock River, made for the use of the Board, is herewith submitted.† These prove much in excess of present low-water discharge measurements.

With reference to the assertion that the northern line and terminus afford greater facilities for commerce and, especially, more free access by land than the southern, the Board have personally observed by inspecting the vicinity that any practicable line along either the north or south bank of Rock River for a half mile or more near the Mississippi must be located upon lands submerged at high stages of the Mississippi; that immediately adjacent to, and bordering, any practicable improvement on either route are extensive areas of land above the highest stages of water in the rivers, easily approached by all means of land transportation and affording ample opportunities for elevators, railroad tracks, and highways; and that a canal located upon either bank can enter the Mississippi River at points of practicable access by Mississippi River steamboats. But to enable Mississippi River steamboats to enter a canal along the north bank of Rock River at all stages of water without constant dredging, the works via the northern line must be materially modified over the stretch from Turkey Island to the Mississippi River in any event, and, in case the basin desired by the people of Rock Island to be located on the low ground north of Turkey Island were constructed, the works along this line would require modification from Sear's Canal to the Mississippi River at increased cost.

It was observed by the Board that all arguments presented to it in favor of the northern route, by the gentlemen who appeared before it from Rock Island, were based not so much upon the supposed superior advantages of the northern line, as proposed in the plans submitted to Congress (which route terminates at the principal mouth of Rock

(*) The only records of low-water discharge of Rock River known when making the detailed plans submitted to Congress June 27, 1890, were (1) G. P. Low (Report Chief of Engineers 1871, pages 304, 305) October 11, 1870, at Dixon = 2,446 cubic feet per second.

(2) G. H. Boynton, C. E., and C. H. Stoddard, Chief Engineer, at head of Carr's Island, survey May and June 1879 (map).

Discharge at low water = 3,931 cubic feet per second.

Discharge at low water 1,139 feet above low water = 5,316 cubic feet per second.

† Not printed.

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River), as upon some line in connection with the basin just named (to be constructed upon the low depression in the mainland north of Turkey Island), and with an entrance into the Mississippi north of Pettifers Island or by way of a canal constructed through the island.

As already stated by the Board, the low-water discharge of Rock River, exclusive of South Slough (1,500 to 1,650 cubic feet per second), is insufficient to maintain a practicable channel for such navigation as is contemplated from the foot of Turkey Island to the mouth of Rock River, through moving sands, by the aid of wing dams. If the north side of Rock River be followed, therefore, the canal must be carried to the Mississippi River. This must be done either by continuing the section of canal below Sear's Canal at the same level as now contemplated, submerged at high water (in which case the basin desired by Rock Island would be of variable level), or by carrying the level of the upper pool, which is practically the same as extreme high water in the Mississippi River, from Sear's Canal to that river.

The former plan would add to the cost of the northern line by the excess of cost of the excavation of the canal and basin over that of the wing dams below the foot of Turkey Island.

The second plan would require an embankment above high water, in the bed of Rock River and on Turkey Island, from Sear's Canal to the depression before mentioned or a canal cut in the plateau from Sear's Canal to the low ground named; an embankment around the proposed basin; the construction of a short section of canal from the basin to the Mississippi River, with a lock of 17-foot lift to enter the Mississippi River instead of a lock of 8.5-foot lift as now designed. The lock at Sear's Canal would still be required as a guard lock and to enable boats to use Rock River at high stages of water in that stream, all of which modifications would add still more to the cost of the northern route than would the first mentioned.

COST OF THE TWO ROUTES.

The Board has considered the estimates, made by Assistant Engineer Wheeler in his report to Capt. Marshall on routes, dated March 7, 1891, for both routes.

Exclusive of cost of rights of way, which must always be an uncertain element when voluntary purchases are impracticable, these estimates are:

For the northern route	$459,055
For the southern route	393,530
In favor of south line	65,525

In forwarding these estimates Capt. Marshall gave it as his opinion that, while they indicated approximately the relative cost of the two routes, yet they are too low by fully 20 per cent.

The estimates as thus indicated by Capt. Marshall (exclusive of rights of way and legal expenses connected with acquiring the necessary lands, etc.) for the construction of the canal are:

For the northern line	$550,865
For the southern line	472,236
In favor of southern line	78,629

To the above estimates it is to be understood that all costs of rights of way, expenses of condemnation, and damages to property must be added.

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The Board believes that the above estimates approximate the probable cost of the works, as contemplated in the modified northern route estimated upon and of the approved southern line, and that the improvement via the southern route is materially less expensive to construct than that along any line on the north bank, and moreover that no improvement can be secured along the northern route without modifying the plan for that line, which modifications will demand a material increase in the cost of the improvement via the northern route and a materially greater difference in cost in favor of the southern line.

The Board is of the opinion that, as an engineering question, even at the same or somewhat greater first cost, the southern line is undoubtedly preferable, because all constructions along the line are more secure and, with one exception, more easily constructed and more cheaply and easily maintained than those required on the northern route.

The dams are lower, the embankments on better foundations, the material for construction more abundant, and the works, with the one exception of the embankments in the river bed below the mouth of Mill Creek, which will be difficult and expensive, less subject to injury by flood during construction.

Divested of all other considerations than those pertaining solely to the utility of the route for the transportation of freight between the Illinois and Mississippi rivers—that is to say, if no attempt be made to so locate the western terminus of the canal as to especially accommodate the city of Rock Island, it must be apparent to all that it may be located at any point at the mouth of Rock River, as already defined in this report, and that the commerce of the canal can be as well provided for by one route as by another. If this be admitted, the question is reduced to that route and terminus which will be best to navigate and can be constructed at the least cost, with the smallest probable future expenditure for maintenance, and the Board can not hesitate in expressing the belief that were there no city of Rock Island the so-called southern route would be approved by common consent.

This view is supported by the fact that no interests except such as attach to the city of Rock Island appear to object to the location of the canal along the southern route. The representatives of the city of Moline failed to even respond to the Board's invitation to send a deputation to the public meeting held on the 9th instant, thus indicating complete indifference as to the route to be finally occupied; and the representatives of the Business Men's Association of Davenport, Iowa, distinctly stated that the location of the route and western terminus of the canal was a matter of no consequence to them. They want the canal as soon as it can be built and do not care which side of Rock River is to be used in reaching the Mississippi, nor upon which side of its mouth the western terminus is located.

With the information before it, the Board can only reach the conclusion that the western terminus can be as favorably located upon the south side of the principal mouth of Rock River as anywhere else in the vicinity; that in such position it will be as easily accessible by Mississippi River boats; that the actual terminus will not be as accessible to teams approaching from the north side of Rock River below the head of the Lower Rapids, but sufficient basins on the southern route can be as easily approached from considerable areas on the north side of Rock River as if the terminus were on the same side; and from Moline the distance to the pool in Rock River above the head of the Lower Rapids will not be much, if any, greater than to a canal terminus on the northern route or to any other point of the northern route below said pool;

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that a canal along the southern route would be easier of access to teams approaching from the south side of Rock River than if the canal were located along the northern route; that the only railroad now actually reaching Rock River below the head of the Lower Rapids crosses the line of each route, and may therefore be supposed to have equal facilities of access to either; that railroads of the future can not pass Rock River below the head of the Lower Rapids without crossing any canal line that may be located along this reach of the river; that any railroad crossing the Mississippi within a comparatively short distance above the mouth of Rock River would have more ready access to a canal established along the northern route, but such a road could reach a canal south of Rock River either by the tracks of the present railroad or by the construction of an independent bridge and an additional length of track not exceeding 2 miles.

But the city of Rock Island exists and it remains to discuss the question whether the benefits which it would derive from a location of the western terminus of the canal on the northern side of Rock River are of such a character as would justify on the part of the United States generally the sacrifice of the advantages of the southern route at the expense of the appropriations made for this public improvement.

The benefits referred to may be summed up as follows: (1) The city would have more easy access to the canal and its terminus both for teams and railroads. (2) Any traffic arising from the transfer of freights from canal boats to Mississippi River craft, or vice versa, and from the storage of boats in the basin would fall to the citizens of Rock Island.

It seems to the Board that the advantages in the first case, so far as teams are concerned, can only be secured at the disadvantage of teams which would desire to reach the canal from the southward of Rock River; and the latter are, in proportion to their number, entitled to equal consideration with the former. In regard to railroads, it is believed that if the freight to be carried shall warrant the construction of more than the one now crossing all lines which have been proposed for the canal, the controlling corporations will not delay in building them.

In case transfers to any considerable extent become necessary at or near the western terminus of the canal there would be some local profit to the business men of Rock Island, acting as the intermediaries.

But an argument frequently used by the advocates of the construction of the canal by the General Government was that freight could be carried through it to and from all upper Mississippi River points without transfer, with great resulting benefit to the people of the country westward and northward of Rock Island; that is to say, that the canal is to be simply a part of an extended combined canal and river navigation adapted to Mississippi barges and boats, the termini of which system of navigation are not upon the line of the canal.

Undoubtedly, if a basin at the western terminus of the canal section of this system were to become a storage place for a large number of boats, with their crews, a considerable profit would be derived from the supplies required for subsistence of crews, repair of boats, etc. No estimate of this profit is practicable, but it is very doubtful if it would ever approximate the expectations of the advocates of the northern route.

The citizens of Rock Island have devoted much time and money in advocating the construction of the canal and they naturally seek some return for both. In this the Board is in entire sympathy with them, and if any sufficient reason could be found for recommending the location

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of the western terminus of the canal north of the principal mouth of Rock River it would be glad to so recommend. But all the information available, both engineering and commercial (except the local interests of the city of Rock Island, as described), indicates the propriety of adhering to the location approved by the Secretary of War under date of March 25, 1891, and it is recommended that this course be taken.

All of which is respectfully submitted.

O. M. POE,
Colonel, Corps of Engineers, Bvt. Brig. Gen., U. S. Army.
A. MACKENZIE,
Major, Corps of Engineers.
WM. L. MARSHALL,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. Army.

NOTE.—This report was approved by the Secretary of War September 24, 1891.

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APPENDIX K K.

IMPROVEMENT OF RIVERS AND HARBORS ON EASTERN SHORE OF LAKE MICHIGAN.

REPORT OF MAJOR WILLIAM LUDLOW, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Petoskey Harbor, Michigan.
2. Charlevoix Harbor and entrance to Pine Lake, Michigan.
3. Frankfort Harbor, Michigan.
4. Harbor of refuge at Portage Lake, Michigan.
5. Manistee Harbor, Michigan.
6. Ludington Harbor, Michigan.
7. Pentwater Harbor, Michigan.
8. White River Harbor, Michigan.
9. Muskegon Harbor, Michigan.
10. Grand Haven Harbor, Michigan.
11. Holland (Black Lake) Harbor, Michigan.
12. Saugatuck Harbor, Michigan.
13. South Haven Harbor, Michigan.
14. St. Joseph Harbor, Michigan.
15. St. Joseph River, Michigan.
16. Michigan City Harbor, Indiana.

EXAMINATION AND SURVEY.

17. Grand River, Michigan, below Grand Rapids.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 11, 1892.

GENERAL: I have the honor to submit herewith the annual reports relative to the works of river and harbor improvement in my charge for the fiscal year ending June 30, 1892.

Respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers,
Bvt. Lieut. Col., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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K K 1.

IMPROVEMENT OF PETOSKEY HARBOR, MICHIGAN.

The matter of this improvement, in the absence of subsequent legislation, remains as stated in the last annual report.

The act of August 11, 1888, contained provision for a survey of this locality, with reference to its improvement by the construction of a "breakwater and harbor of refuge."

Petoskey is situate on the south shore of Little Traverse Bay, Lake Michigan, toward the northern end of the Lower Peninsular, and the natural "harbor" is little more than an indentation in the shore line at the foot of the elevations on which the town is built.

The investigations made showed clearly that a "harbor of refuge" for the benefit of general commerce was not needed at this point, but that some protection from the weight of the winds from the northwest quadrant, to which the frontage was exposed, was desired in the interest of the considerable freight and passenger traffic of the locality.

Two means of accomplishing this object were submitted with my report under date of December 21, 1889, and printed in the Annual Report for 1890 (pages 2674, 2675). One project was the reconstruction of the existing landing pier of solid crib work, with an L extending eastward, at an estimated cost of $70,000. The other was for a breakwater extending 550 feet offshore from a point westward of the landing to about 26 feet of water, and thence, extending eastwardly about 1,200 feet, so as to overlap the landing and inclose a sheltered area, open to the eastward, of about 12 acres. The estimated cost of this construction was $170,000.

The act of September 19, 1890, made appropriation for "Improving harbor at Petoskey, Mich.: For breakwater and harbor of refuge, $15,000." From this phraseology it was to be inferred that the purpose of the act was to provide for the construction of the larger of the two projects submitted, but the amount allotted was so disproportionate to the estimated cost that it was manifestly impracticable to accomplish any useful result with the means at hand. The estimated cost of the offshore 550 feet of breakwater alone was $35,000, so that the appropriation of $15,000 would construct not more than half of this, and, as no advantage to commerce could accrue from building this portion and leaving it exposed to the action of the sea until its construction could be continued, it seemed injudicious to make any expenditures until further action of Congress. Recommendation to this effect having been made to the Chief of Engineers under date of October 25, 1890, and approved by him, the matter remains in the condition stated.

In order to undertake construction to any advantage the means in hand should be sufficient to build the offshore portion and enough of the outer portion or "breakwater" proper as should serve some useful purpose, say not less than 300 feet. The cost of this would be for the offshore pier $35,000 and for 300 feet of breakwater $30,000, a total of $65,000. The present appropriation is $15,000, and therefore appropriation should be made of $50,000 additional. The 300 feet of breakwater provided for in this estimate is one fourth of the total length projected.

This harbor is in the Michigan collection district. The nearest port of entry is Grand Haven, Mich. The nearest light-house is at Harbor Springs, 4 miles distant, on the north shore of Little Traverse Bay.

Original estimated cost of the breakwater project, 1890	$170,000
Whole amount appropriated, act of September 19, 1890	15,000

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Money statement.

Amount appropriated by act approved September 19, 1890	$15,000.00
July 1, 1892, balance unexpended	15,000.00
Amount appropriated by act approved July 13, 1892 (landing pier project)	20,000.00
Amount available for fiscal year ending June 30, 1893	35,000.00
Amount (estimated) required for completion of landing pier project	35,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	35,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

K K 2.

IMPROVEMENT OF CHARLEVOIX HARBOR AND ENTRANCE TO PINE LAKE, MICHIGAN.

The improvements at this harbor include the lower channel leading from Lake Michigan into Round Lake and the upper channel leading from Round Lake into Pine Lake.

The present project, adopted in 1868 and revised in 1876 and 1884, is for a 12-foot navigation, 100 to 150 feet wide in the lower channel and 83 feet wide in the upper channel.

The lower channel is protected on the north side by 302 linear feet of crib work built by the United States, 469 linear feet of crib work built by the local authorities previous to 1873, and 945 linear feet of plank-beam revetment built by the United States, with a timber frame work 40 feet long covering the gap between the crib work and the revetment, overlapping the latter about 30 feet. The total length of pier and revetment is 1,724 linear feet, and the projection of the pier beyond the present shore is about 740 feet.

The projection on the south side consists of 491 linear feet of crib work and, with the 50-foot wing at the Round Lake end, of 1,538 linear feet of close piling and plank-beam revetment. The total length of this work is 2,029 linear feet, and its projection beyond the present shore line is 400 feet.

The upper channel is protected on the north side by a pile revetment 339 feet long and on the south side by a similar revetment 366 feet long. Both revetments are filled with brush and stone ballast.

The dredging done in May and June, 1891, was instrumental in maintaining a navigable depth of water until the end of the season, but soundings made March 30, 1892, showed a depth of but 10 feet near the end of the outer pier and through the upper channel.

This decrease in depth is partly owing to the extraordinary low lake level, but principally to the insufficient projection of the piers and the temporary nature of the older parts of the piers and revetments. A survey made on March 30, 1892, showed a depth of but 10 feet in Lake Michigan 170 feet in advance of the South Pier, the shoal extending entirely across the entrance, and, although the present project provides for an addition of 100 linear feet to the South Pier (the North Pier already having its projected length), it is evident that a further extension of both piers is needed, if even a 12-foot navigation is to be maintained.

As has been said above, 470 linear feet of the North Pier was built at local expense, previous to 1873, when the Government took charge

of the improvement. This work is a crib structure, rudely built and placed on the natural bottom, and, as a result, extends only to a few feet below the water surface. It has been repaired and refilled with stone from time to time, but is now fast disintegrating. It has never been possible to dredge close up to it, because it would have been undermined thereby and consequently wrecked.

Large quantities of sand find their way through it into the channel at every blow, and it is impossible to prevent this so long as the present work remains.

The original project contemplated its removal and the substitution of a more serviceable and durable structure, and the time for this change is close at hand.

The revetments of the lower channel are of a temporary nature. The channel is narrow, with high sand banks on each side, and it was necessary to resort to rapid construction in order to hold the banks while the channel was making.

The portion above water is rapidly decaying, and particularly the south revetment, owing to its exposed position with respect to colliding vessels, is in great need of strengthening and repairing. Both revetments should be rebuilt above the water surface and provided with a double row of sheet piling and anchor piles in rear.

Owing to the fact that the north revetment has never been fully completed, stopping at the lake side of the highway bridge that spans the entrance, and the bank above the bridge has been built out with slabs as wharfage for the sawmill, the north draw of the bridge is not navigable and passage is confined to the south draw. This matter has not received special attention since the south draw seems, so far, adequate to the commerce of the port, and no complaints of obstructions have been received. It may be well, however, to note these conditions for future reference.

The revetments of the upper channel are also in need of extension to reach into Pine Lake.

The operations during the fiscal year consisted in generally overhauling and repairing the revetments of the lower channel. The broken caps and guard timbers were renewed, additional piles were driven to strengthen the works, and the gap between north pier and revetment at shore line was filled with brush fascines, loaded with large stone picked up on the beach.

A permanent benchmark was established on top of the water table at northeast corner of the opera-house block and connected by duplicate levels with the United States gauge, and a careful series of water-gauge readings was commenced June 1, 1892, to continue through the months of June, July, and August for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

The bridge of the Chicago and North Michigan Railroad across the lower end of Pine Lake has been completed and is found to be located and built in accordance with the plans approved by the Secretary of War under date of September 4, 1891.

The Government dredge *Saginaw* is now on the way to the harbor to deepen the entrance and both channels.

The present working balance is $2,300, about half of which will be required to pay for dredging and the remainder will be held for minor repairs.

For 1894 the estimate is, for two cribs in the south pier, to complete

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it according to the present project, $9,500; rebuilding 500 feet of inner end of north pier, $15,000; sheet piling 2,450 linear feet of plank-beam revetment, $12,500; and extending the revetments of the upper channel 1,200 linear feet, $7,200. The total cost of these items, with $3,000 for dredging during two seasons and 10 per cent for contingencies, is $52,000.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

The light-house establishment maintains a fifth-order light on the north pier.

Appropriations for improving harbor at Charlevoix, Mich.

August 14, 1876	$10,000	August 5, 1886	$10,000
June 18, 1878	12,000	August 11, 1888	12,500
March 3, 1879	9,000	September 19, 1890	9,000
June 14, 1880	10,000		
March 3, 1881	10,000	Total	102,500
August 2, 1882	10,000		
July 5, 1884	10,000		

Original estimated cost of work, 1868, as amended in 1876 and 1884	$186,000.00
Whole amount appropriated from 1868 to and including act of September 19, 1890	102,500.00
Whole amount expended to June 30, 1892	99,944.24

Money statement.

July 1, 1891, balance unexpended	$6,230.20
June 30, 1892, amount expended during fiscal year	3,674.44
July 1, 1892, balance unexpended	2,555.76
July 1, 1892, outstanding liabilities	247.12
July 1, 1892, balance available	2,308.64
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	12,308.64

Amount (estimated) required for completion of existing project	73,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	52,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, CHARLEVOIX HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	772	$355.46	
1885	599	779.53	
1886	674	390.46	
1887	753		151,360
Calendar year:			
1888	526		92,306
1889	473		
1890	532		75,224
1891	534		79,613

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*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Beer.....barrels..	75	8	Bark.....cords..	7,764	7,764
Coal.....tons..	.....	2,936	Fish.....tons..	.....	25
Feed.....bushels..	200	5	Hay.....do...	.....	30
Flour.....barrels..	320	32	Hoops.....bundles..	6,500	162
Grain.....bushels..	990	1,237	Lath.....M..	617	185
Hay.....tons..	.....	508	Lime.....tons..	.....	150
Machinery.....do...	.....	15	Lumber.....M. feet, B. M..	14,899	26,073
Merchandise.....do...	.....	447	Merchandise.....tons..	.....	40
Salt.....barrels..	185	26	Pig iron.....	.....	550
Steel rails.....tons..	.....	1,642	Posts, cedar, No. 3...number..	115,470	62,309
Shingles.....M..	1,113	139	Potatoes, bushels.....	4,300	129
Stone.....tons..	.....	1,676	Shingles.....M..	70	9
			Ties.....number..	981,470	83,832
			Wood.....cords..	5,505	8,258
Total.....	.....	8,671	Total.....	.....	189,516

* Compiled from statements furnished by the collector of customs and by the mayor of Charlevoix.

KK 3.

IMPROVEMENT OF FRANKFORT HARBOR, MICHIGAN.

The project for this harbor, adopted in 1866 and amended in 1868 and 1879, provides for a channel 200 feet wide and 12 feet deep, protected by piers and revetments.

The original facilities for navigation previous to the commencement of the improvement by the Government in 1866 consisted in a channel 70 or 80 feet wide, with a depth of 3 to 4 feet. These conditions have been greatly improved and at the present time, with the help of occasional dredging, a depth of 10 to 12 feet is maintained.

The survey made March, 1892, shows that the 10-foot contour in the lake is about 250 feet in advance of the end of the north pier, and, in consequence of this insufficient development, frequent dredging is required to maintain the needed depth at the entrance. The depth across the outlying bar was found this spring to be 11 feet, but the 15-foot contour is immediately beyond, about 420 feet outside of the present end of the south pier, and thence outwards the lake deepens rapidly, the offshore contour swinging boldly in towards the land.

It is evident that the piers should be built out to at least the 15-foot curve, but the pier development provided for by the present project, viz, 300 feet on the north pier and 100 feet on the south pier, falls 500 feet short of this on the north and 400 feet on the south pier.

At the beginning of the fiscal year the available depth at the entrance was 10 feet and on the 21st of July the Government dredge *Saginaw* arrived to prepare better water. The channel was dredged throughout, 70 feet wide, from Lake Michigan to about shore line, and 40 feet wide from there to Lake Aux Becs Scies, and 14 feet deep, and quantity of sand removed was 22,770 cubic yards. The dredging was completed August 20, 1891.

During the remainder of 1891 no further difficulty was encountered by the vessels frequenting the harbor, but at the opening of navigation this spring a depth of only 11 feet was found on the bar in front of the entrance, and the shoal overlapping the end of the north pier

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had encroached considerably on the channel between the piers. Towards the end of the fiscal year, however, there was a navigable depth of 13 feet, in great part due to the rise in the lake level.

The required material for making some minor repairs to the piers and revetments, and for sheet piling the latter to make them sand tight, has been purchased, and this work will be done as soon as the land driver can be spared for use at this harbor.

A permanent bench mark was established at the northwest corner of the water-works building, on top of the water table and connected by duplicate levels with the U. S. gauge, and a careful series of water-gauge readings was commenced June 1, 1892, to be continued through the months of June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

The present working balance is about $4,400, with which it is proposed to sheet-pile the revetments, make some minor repairs to the existing works, and to pay for the necessary dredging restore the entrance channel to the required width and depth.

The Toledo, Ann Arbor, and North Michigan Railway proposes making Frankfort a terminus for the establishment of a new trans-lake line by means of a system of steam ferries for transportation of cars without breaking bulk. The experiment is one of great importance and its success would be a notable event in the development of lake business.

For 1894 the following estimate is submitted:

To complete the present project by adding 300 linear feet of crib work to the north pier, $28,500; and 100 linear feet of crib work to the south pier, $12,000; for additional repairs, $2,000; and for two seasons dredging, $5,000, which, with 10 per cent for contingencies, makes $52,000.

The light-house establishment maintains a sixth-order light near the end of the south pier, and the Life-Saving Service a station at the inner end.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven.

Appropriations for improving harbor at Frankfort, Mich.

Aux Becs Scies:	
June 23, 1866	$88,541.00
March 2, 1867	10,000.00
July 25, 1868	10,000.00
April 10, 1869	29,318.85
July 11, 1870	10,000.00
March 3, 1871	10,000.00
Frankfort, Mich.:	
June 10, 1872	10,000.00
March 3, 1873	10,000.00
June 23, 1874	10,000.00
March 3, 1875	10,000.00
August 14, 1876	3,000.00
Frankfort, Mich.:	
June 18, 1878	$8,800.00
March 3, 1879	4,000.00
June 14, 1880	5,000.00
March 3, 1881	10,000.00
August 2, 1882	15,000.00
July 5, 1884	5,000.00
August 5, 1886	7,000.00
August 11, 1888	8,000.00
September 19, 1890	10,000.00
Total	273,659,85

Original estimated cost of work in 1866, as amended in 1868, 1879, and 1892	$329,655.85
Whole amount appropriated from 1866 to and including act of September 19, 1890	273,659.85
Amount covered into the Treasury (Report 1871, page 133)	5,721.50
Whole amount expended to June 30, 1892	263,511.86

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Money statement.

July 1, 1891, balance unexpended	$8,056.08
June 30, 1892, amount expended during fiscal year	3,629.59
July 1, 1892, balance unexpended	4,426.49
July 1, 1892, outstanding liabilities	10.00
July 1, 1892, balance available	4,416.49
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	14,416.49
Amount (estimated) required for completion of existing project	500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	42,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, FRANKFORT HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	488	$404.70	.....
1885	261	75.66	.....
1886, 1887, 1888	(*)	(*)	.....
Calendar year:			
1888	1,342	.....	216,376
1889	(*)	(*)	.....
1890	443	.....	57,140
1891	1,541	.....	258,908

* Not stated.

*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Beer ..... barrels	80	8	Bark ..... cords	7,416	7,416
Coal ..... tons	.....	125	Fish ..... tons	.....	205
Flour ..... barrels	500	50	Fruit ..... do	.....	412
Feed ..... tons	.....	192	Lumber ..... M feet B. M	17,571	30,749
Grain ..... bushels	10,460	288	Potatoes ..... bushels	3,000	90
Hay ..... tons	.....	500	Posts	8,000	160
Iron ..... do	.....	50	Shingles ..... M	3,060	458
Lath ..... M	50	15	Slabs ..... cords	2,425	6,518
Live stock ..... head	125	22	Ties	5,100	459
Machinery ..... tons	.....	6	Wood ..... cords	4,370	7,416
Lime and cement ..... do	.....	100			
Merchandise ..... do	.....	1,050	Total	.....	53,883
Stone ..... do	.....	100			
Total	.....	2,506			

* Compiled from statement furnished by the collector of customs and by the mayor of Frankfort.

K K 4.

IMPROVEMENT OF HARBOR OF REFUGE AT PORTAGE LAKE, MICHIGAN.

The official project adopted in 1879 and modified in 1880–'81, is to make this a harbor of refuge with a channel 370 feet wide and 18 feet deep, protected by piers and revetments.

The north pier consists of 1,240 linear feet of pile work filled with edgings, and 151 feet of crib work, and projects 550 feet beyond the present shore line.

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The south pier is a pile and edging structure 1,380 feet long, and projects 550 feet beyond the present shore line.

As stated in the previous Annual Report, the revetments are in a ruinous condition. On the north side the superstructure timbers have either totally disappeared, or are made unserviceable by the failure of the cross-ties; the filling has washed out for a length of some 400 linear feet, giving the sea a clean sweep through the work and filling the channel with sand from the beach and banks, and the piles of the side walls are for a considerable stretch pushed out of position to such an extent that they are useless. The outer half of the south pier is almost as bad, and, in short, almost the whole pile work should be removed and replaced by more substantial structures.

While the present pile piers and revetments, if they were in serviceable condition, would be of some benefit, they would not of themselves insure a navigable depth of water in the channel. At present the 10-foot curve in the lake passes nearly 250 feet outside of the end of the south pier.

Soundings made in May, 1892, showed a narrow and crooked channel with less than 7 feet water between the piers, and the Government dredge *Saginaw* was sent to improve the navigation. The dredge arrived on June 3, and to June 29 completed a cut 40 feet wide and 13 feet deep from lake to lake, removing 20,284 cubic yards.

No attempt has been made to expend any part of the available balance to the credit of the harbor on repairs to the revetments, for it would have been so much money wasted, inasmuch as nothing but radical treatment will make them useful.

A permanent bench mark was established and connected by duplicate levels with the United States gauge, and a series of accurate water-gauge readings was commenced June 1, 1892, to be continued through the months of June, July, and August for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

The present working balance of $4,100 will be used in keeping the entrance partially accessible by dredging, and to do such repairing as is practicable.

Notwithstanding this exhibit it still remains, as stated in the reports for the last two years, that the natural conditions at Portage Lake, its broad expanse, ample depth, and central position in the dangerous bight of 50 miles between Point Betsey and Little Point Sable, justify the purpose of the original project, and warrant renewed recommendation that this project be carried out.

A harbor of refuge is needed in this locality, as there is no safe shelter or anchorage in westerly gales between Ludington and South Manitou.

For 1894 the recommendations of the previous Annual Report are renewed, viz, for 4 cribs, 200 feet, on north pier, $20,000; for 7 cribs, 350 feet, on south pier, $33,000 (these constructions being in each case one-half of the projected crib piers); for rebuilding 1,240 linear feet of old north pier, $38,000; sheet piling and filling, $6,000, and for dredging, 10,000. The total of these, with allowance for contingencies, etc., is $125,000.

The Light-House Establishment has recently constructed a fourth-order light-house near the end of the north pier, upon the only portion of the harbor works capable of sustaining it.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

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Appropriations for harbor of refuge at Portage Lake, Michigan.

March 3, 1879	$10,000	August 5, 1886	$15,000
June 14, 1880	10,000	August 11, 1888	10,000
March 3, 1881	10,000	September 19, 1890	8,000
August 2, 1882	25,000		
July 5, 1884	12,500	Total	100,500

Original estimated cost of work, 1879, as amended in 1890	$267,500.00
Whole amount appropriated from 1889 to and including act of September 19, 1890	100,500.00
Whole amount expended to June 30, 1892	95,055.92

It has been impracticable to obtain commercial statistics for Portage Lake Harbor.

Money statement.

July 1, 1891, balance unexpended	$7,458.15
June 30, 1892, amount expended during fiscal year	2,014.07
July 1, 1892, balance unexpended	5,444.08
July 1, 1892, outstanding liabilities	1,337.47
July 1, 1892, balance available	4,106.61

Amount (estimated) required for completion of existing project	167,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	125,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

K K 5.

IMPROVEMENT OF MANISTEE HARBOR, MICHIGAN.

The project of 1866, modified in 1870, 1874, and 1890, provides for a channel of navigable width and 15 feet deep, extending from Lake Michigan to Manistee Lake, and protected at the entrance by piers and revetments. With the cribs placed during the season of 1891 the piers and revetments have the following development:

North pier, 1,251 linear feet crib work and 1,304 feet of pile revetment. It projects 850 feet beyond present shore line.

South pier, 1,199 linear feet crib work and 490 feet pile revetment. It projects 650 feet beyond present shore line.

At the beginning of the fiscal year a contract was in force with C. H. Starke to complete the dredging of the river to Manistee Lake, and this work was completed August 28. Before leaving the dredge went again over the work of the previous season so that at the end of August there was a through channel 50 feet wide and 15 feet deep from lake to lake, the width being increased to 75 feet at the bend opposite Canfield & Wheeler's sawmill and to 100 feet at the entrance. The material removed during the fiscal year measured 40,784 cubic yards. An examination made in May, 1892, showed that the depth in the river was diminished to 13 feet, with 15 feet at the entrance, which, however, may be looked upon as very good when the long reaches of unprotected bank along the river and the great number of vessels of all sizes using the navigation are taken into consideration.

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The depth at the entrance will continue to be unreliable until the piers shall have been built out to their projected length, which requires an addition of 350 feet to each pier.

The contract with George W. Crouter for the construction of four cribs on the north pier, which was under way at the commencement of the fiscal year, was completed in September, 1891. The cribs were each 50 feet long, 24 feet wide, and with the superstructure 22 feet 8 inches high. They rest on a pile foundation at a depth of 16 feet 3 inches below the zero of the gauge, the piles penetrating from 15 to 17 feet into the bottom. The top of the superstructure is at the same level as that of the adjacent old work, viz, 6 feet 5 inches above zero of gauge. At the outer end the new work is protected by a structure of guard piles and horizontal waling timbers, filling the space between the end horns, and a mooring post is built into each crib. The cribs were filled with stone and decked over. The actual addition to the length of the pier by the four cribs is 202 linear feet.

Before final acceptance of the work it was examined by a diver and found to be satisfactory.

The north revetment being in a tumble-down condition, the part from Station 3+24 to the life-saving station, a distance of 764 linear feet, was cut down to the water surface and rebuilt with four courses of superstructure. The old filling was taken out and the suitable portion replaced in a substantial manner in the work, reaching as high as the lower cross-ties and ballasted with old stone. The sink and water holes along the rear of the work due to seepage and subsidence were filled up with the old filling.

A passage 8 feet wide for the light-keeper's boat was prepared through the new work at Station 7+61 to 7+69.

The upper part of the north pier, Station 14+90 to 15+50, a distance of 60 feet, where the side walls were crumbling away and the filling exposed to the danger of sliding into the channel, was repaired, the projecting part of the square crib in the south pier (Station 6+16 to 6+46) was repaired and decked, and a plank walk was laid on south pier from the inner end to the fog-horn house, a distance of 800 feet.

All the above repairs were made by day labor and purchased material, commencing the work in September, 1891, and completing it in June, 1892, operations having been suspended during the winter months.

A permanent bench mark was established and connected by duplicate levels with the United States gauge, and a series of accurate water-gauge readings was commenced June 1, 1892, to be continued through the months of June, July, and August for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

At the present time the existing works are in the following condition:

North pier.—The revetment from the inner end to Station 3+24, a distance of 390 feet, is in urgent need of new superstructure. The north revetment is exceptionally exposed to wear and tear, the sailing vessels frequenting the harbor being in the habit of tying up here during stormy weather on the lake or while waiting for a cargo. The part from Station 3+24 to the life-saving station, a distance of 764 feet, has now been rebuilt, and the rest should be repaired likewise as soon as possible to prevent it from being totally wrecked.

The part from the life saving station to 12+38, a length of 130 feet, should be treated in the same manner. Oak snubbing posts should be

secured to the rear wall at distances of 50 feet along this whole work to keep vessels from making fast to the cross-ties, which is one of the main causes of the early ruin of the structure.

The north pier from Station 12+38 to 18+83, a distance of 645 feet, is now more than 20 years old, and the part above water, although patched and repaired from time to time, is in urgent need of rebuilding. It is continually giving away in places, and it is getting more and more difficult to repair it, as the old timber is too rotten to hold a bolt. Most of the cross-ties are rotten and broken.

The part from Station 18+83 to the outer end, a distance of 606 feet, is in good condition, but needs some additional filling in the new cribs and some stone riprap along the foot of the lake wall to prevent its being undermined. This should be done before another winter.

South pier.—The inner end consists of some 490 linear feet of pile revetment, built in 1874 and 1875. This work is occupied by the Canfield and Wheeler Lumber Company as a lumber wharf, and in consequence of age and hard usage is completely wrecked. It seems no longer capable of carrying the load placed on it and threatens to cave into the channel. If continued as a part of the lumber yard the company may properly be called upon to rebuild it.

The south pier from Station 0 to 6 + 46, 646 linear feet, is crib work, built previous to 1872. At its inner end it is breaking down, but the remainder is still in tolerably fair condition, and will stand some years yet. From 6 + 46 to the outer end, 451 linear feet, the pier is in good condition.

With the present working balance of $4,800 it is proposed to purchase about 150 cords of stone for refilling the end of north pier and riprapping the foot of the lake wall, to make minor repairs, and to reserve the rest for dredging the entrance when necessary.

The recommendation for 1894 is as follows: For seven cribs, 350 feet, on the north pier; and seven cribs, 350 feet, on the south pier, to complete the present project, $84,000; for repairing 645 linear feet of north pier, $6,450; for repairing 500 linear feet of north revetment, $3,500, and for two seasons' dredging in the harbor, $4,000; which, with contingencies, make $110,000.

The Light-House Establishment maintains a sixth-order light and steam fog signal on the south pier, and the Life-Saving Service has a station near the inner end of the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at Manistee, Mich.

March 2, 1867	$60,000	June 4, 1880	$10,000
July 11, 1870	20,000	March 3, 1881	10,000
March 3, 1871	9,000	August 2, 1882	15,000
June 10, 1872	10,000	July 5, 1884	10,000
March 3, 1873	10,000	August 5, 1886	10,000
June 23, 1874	10,000	August 11, 1888	10,000
March 3, 1875	25,000	September 19, 1890	50,000
August 14, 1876	14,000		
June 18, 1878	15,000	Total	298,000
March 3, 1879	10,000		

Original estimated cost of works, 1866, as amended in 1871, 1873, and 1875, 1890, and 1892	$408,000.00
Whole amount appropriated from 1866 to and including act of September 19, 1890	298,000.00
Whole amount expended to June 30, 1892	292,669.31

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Money statement.

July 1, 1891, balance unexpended	$35,090.94
June 30, 1892, amount expended during fiscal year	29,760.25
July 1, 1892, balance unexpended	5,330.69
July 1, 1892, outstanding liabilities	510.52
July 1, 1892, balance available	4,820.17
Amount appropriated by act approved July 13, 1892	50,000.00
Amount available for fiscal year ending June 30, 1893	54,820.17
Amount (estimated) required for completion of existing project	25,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	60,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, MANISTEE HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	3,609	$3,181.19	.....
1885	3,560	1,145.29	.....
1886	3,352	634.26	.....
1887	3,412	.....	991,872
1888	3,459	.....	889,879
Calendar year:			
1888	3,595	.....	966,221
1889	3,524	.....	945,329
1890	3,691	.....	975,049
1891	3,617	.....	1,079,818

*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Beer ... barrels	610	61	Bark ... cords	7,528	7,528
Brick ... M	528	1,325	Coal ... tons	.....	1,700
Coal ... tons	.....	6,699	Fish ... do	.....	487
Eggs ... dozen	27,658	17	Fruit ... do	.....	300
Flour ... barrels	13,221	1,322	Furniture ... do	.....	75
Feed ... tons	.....	1,181	Lime and cement ... barrels	250	33
Gravel ... do	.....	6,500	Lumber ... M feet	283,320	495,810
Grain ... bushels	129,800	3,570	Lath ... M	27,452	8,236
Hay ... tons	.....	757	Machinery ... tons	.....	50
Iron ... do	.....	200	Merchandise ... do	.....	1,869
Live stock ... head	198	35	Posts ... number	113,140	2,263
Lime and cement ... barrels	1,000	130	Potatoes ... bushels	86,000	2,580
Machinery ... tons	.....	250	Salt ... barrels	1,077,162	150,851
Merchandise ... do	.....	14,500	Slabs ... cords	2,849	7,658
Oil ... barrels	20	4	Shingles ... M	154,041	19,255
Pork ... do	2,300	230	Stone ... tons	.....	625
Sugar ... do	273	68	Wood ... cords	665	998
Vinegar ... do	123	12			
Stone ... tons	.....	6,250	Total	.....	700,318
Total	.....	43,201			

* Compiled from statements furnished by the collector of customs and by the mayor of Manistee.

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K K 6.

IMPROVEMENT OF LUDINGTON HARBOR, MICHIGAN.

The project adopted in 1867 and modified in 1885 and 1890 provides for a channel 200 to 250 feet wide and 18 feet deep, protected by piers and revetments.

The development of the protection works is as follows:

North pier consists of 1,452 linear feet of crib work, built between 1868 and 1890, and projects 960 feet beyond the present shore line. At its inner end it connects with an old slab revetment, built at private expense, and now in a tumble-down condition.

South pier consists of 567 linear feet of pile work, built 1872 to 1875, and of 1,814 linear feet of crib work, built between 1868 and 1891. It extends along the entire channel from Pere Marquette Lake to Lake Michigan and projects into the latter 1,560 feet.

Considerable portions of the present works are very old and need renewal above the water line, particularly the part of north pier from Station 5+88 to 12+36, a distance of 648 feet, the pile structure on the south side 567 feet long, and the south crib work from Station 5+67 to 14+23, 856 linear feet.

The mentioned parts of the north pier especially are in need of repairs in consequence of serious abrasions by colliding vessels and the undermining action of steamers.

The remaining structures are in good condition and only need some additional stone ballast and riprap around the outer ends of the two piers.

The dredging by Government plant, which was under way at the beginning of the fiscal year, was continued till July 20, by which time a channel 18 feet deep and 40 feet wide, extending from lake to lake, had been excavated.

The Government dredge returned to the harbor early in November, but the season was too far advanced to allow of much work. However, the worst portion of the channel was again deepened, and no trouble was experienced by the vessels frequenting the harbor during the winter on account of insufficient water.

The quantity of sand removed during the year was 19,397 cubic yards. The available depth when surveyed in April, 1892, was found to be nowhere less than 14.5 feet, the lake level being 1½ feet below the zero plane.

In order to remove any doubts regarding the stability of the cribs placed in extension of the two piers during 1889 and 1890, the foundations were again examined by a diver in September, 1891, and no further changes discovered. During the winter the dredge *Saginaw* received such repairs to machinery, etc., as were needed to place her in condition for the coming season's work.

A permanent bench mark was established and connected by duplicate levels with the United States gauge. The bench mark is on stone window-sill of south window, east face of pump-house of water works, and is 9.08 feet above the zero of the gauge. A series of accurate water-gauge readings was commenced June 1, to be continued during June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

It is proposed to use the balance available July 1 ($3,100) for dredging when necessary, and for minor repairs and stone filling and riprap.

The estimated requirements are as follows: Rebuilding above water

648 linear feet of north pier, $6,480; 567 linear feet of south revetment, $4,540, and 856 linear feet of south pier, $8,560, and dredging, $4,000, which, with 10 per cent for contingencies, makes $26,000.

The Light-House Establishment maintains a sixth-order light near the end of the south pier and the Life-Saving Service has a station near the inner end of the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at Ludington, Mich.

March 2, 1867	$50,000	March 3, 1879	$5,000
April 10, 1869	31,185	June 14, 1880	8,000
July 11, 1870	10,000	March 3, 1881	10,000
March 3, 1871	10,000	August 2, 1882	12,000
June 10, 1872	10,000	July 5, 1884	10,000
March 3, 1873	25,000	August 5, 1886	56,250
June 23, 1874	20,000	August 11, 1888	60,000
March 3, 1875	10,000		
August 14, 1876	10,000	Total	352,435
June 18, 1878	15,000		

Original estimated cost of the work in 1866	$270,632.00
Additional cost project of 1885	419,185.20
Or, as revised in 1890	378,435.00
Cost of project, to complete, as modified and adopted in 1890	111,000.00
Whole amount appropriated from 1868 to and including act of August 11, 1888	352,435.00
Whole amount expended to June 30, 1892	349,216.57
Amount carried to surplus fund	.90

Money statement.

July 1, 1891, balance unexpended	$9,595.17
June 30, 1892, amount expended during fiscal year	6,377.64
July 1, 1892, balance unexpended	3,217.53
July 1, 1892, outstanding liabilities	18.61
July 1, 1892, balance available	3,198.92
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	8,198.92
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	21,000.00

COMMERCIAL STATISTICS, LUDINGTON HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	2,047	$1,451.81	.....
1885	1,468	425.57	.....
1886	1,565	520.57	.....
1887	1,442	.....	259,800
1888	1,511	.....	270,316
Calendar year:			
1888	1,778	.....	277,074
1889	1,759	.....	.....
1890	2,270	.....	461,997
1891	2,420	.....	610,057

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*Receipts and shipments by vessel, 1891.**

	Tons.
Receipts:	
Agricultural implements	161
Beef, dressed	606
Cement, brick, sand, etc	1,015
Flour	114,553
Fruit and vegetables	388
Grain	35,226
Furniture	904
Hides and leather	2,845
Live stock	234
Lumber	355
Meal, bran, and mill stuff	25,170
Manufactures	127
Machinery and castings	168
Merchandise	10,092
Poultry, pork, game, and fish	72
Petroleum	178
Wine, beer, and liquors	1,479
Wool	167
Wagons, carriages, etc	29
Total	193,769
Shipments:	
Forest products	979
Furniture	339
Fruit and vegetables	630
Flour and meal	16
Hides and leather	6
Live stock	134
Lumber and shingles	344
Manufactures	3,549
Machinery and castings	27
Merchandise	18,817
Poultry, pork, game, and fish	26
Rails	2,164
Stone	7
Salt	60,379
Total	87,417

KK 7.

IMPROVEMENT OF PENTWATER HARBOR, MICHIGAN.

The present project, adopted in 1866 and amended in 1873, 1875, and 1883, provides for a 12-foot navigation between piers and revetments 150 feet apart.

The north pier consists of 402 linear feet of crib work at the Lake Michigan end, and 1,821 linear feet of pile work extending to Pentwater Lake. It projects into Lake Michigan about 600 feet.

The south pier consists of 723 feet of crib work and 1,392 feet of pile work, the inner 250 feet of which, from the ferry slip to Pentwater Lake, was built by the Chicago and West Michigan Railway. It projects about 580 feet beyond the present shore line.

The present project provides for an addition of 200 linear feet to the south pier, but the north pier has its projected length.

Although the protecting structures have so nearly attained their

* Compiled from statement received from G. W. Ledlie, auditor Flint and Pere Marquette Railway Company.

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projected length, the intended depth of 12 feet can not be maintained without repeated dredging, and this is caused partly by the inefficiency of the inshore revetments to exclude the sand, and partly by the advance of the shore line since the project was made.

The 10-foot curve of Lake Michigan is about even with the present end of the south pier, and the 15-foot curve is 400 feet farther out. It is evident that the piers are in need of additional length if the proposed depth of 12 feet is to be maintained between them.

Considerable portions of the piers and revetments, from age and accident, have become inoperative in excluding the sand coming from the beach and banks, and are in urgent need of repairs.

The north pier crib work from Station 1+51 to 3+50 and the pile work from 3+50 to 6+72, a total length of 521 feet, and the south pier crib work from Station 0 to 6+19, a length of 619 feet, are now more than 20 years old and should be rebuilt above the water line. The south side revetment has been been rebuilt during recent years, as rapidly as the funds permitted, 725 linear feet, Station 6+19 to 13+44 having received new superstructure, but the inner end from Station 13+44 to 17+61, a length of 417 feet, still remains to be treated in the same manner. In addition most of this pile work needs sheet piling along the rear to make it sand tight.

The 250 feet of railroad bulkhead at the inner end of the south revetment is in a tumble-down condition; the piles are decayed; it is quite devoid of filling, and large quantities of sand are sucked through it into the channel by the action of passing vessels.

The inner end of the north revetment has been wrecked by collisions and needs rebuilding.

At the beginning of the fiscal year the available depth of water in the channel was 10 feet, and August 18 the Government dredge *Farquhar* commenced improving the waterway, completing this work October 6. During this time a 50-foot channel 14 feet deep was dredged from Pentwater Lake to Lake Michigan, removing therefrom material to the amount of 15,395 cubic yards.

No further trouble was experienced during the year, but soundings made April 11, 1892, showed that the channel had again filled up, a length of about 600 feet near the shore line having barely 10 feet of water. It is intended to send a dredge to this harbor as soon as practicable.

The repairs of the south revetment, which were under way on July 1, were completed November 30, the work having been suspended during two and a half months of this time, to utilize the services of the overseer on the improvement of the St. Joseph River. The repaired portion extends from Station 8+88 to 13+44, a distance of 456 feet. The piles were sawed off, and a new superstructure four courses high in front and two courses high in rear with cross-ties 8 feet apart, built on top; the old filling was overhauled to below the water line and new edgings and stone placed in the work.

A plank walk was laid over the south revetment for a length of 1,096 feet to connect with the elevated walk to the pier light.

A permanent bench mark was established on top of a large bowlder projecting from the foundation of the Sands & Maxwell furniture factory, on the southwest corner, and connected by duplicate levels with the United States gauge, and a series of accurate water-gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

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It is proposed to use the balance available July 1 ($2,400) for redredging the entrance and for minor repairs.

The needs of the harbor have been outlined above. To meet these requirements, the following estimate is submitted: For 4 cribs for south pier (to complete the present project), $24,000; for rebuilding above water and refilling 521 feet of north pier, 619 feet of south pier and 417 feet of south revetment, 1,557 feet in all, $15,570; for sheet piling 1,050 feet of north pier and revetment and 780 feet of south revetment, a total of 1,830 feet, $5,490; and for dredging, $3,000; which, with an estimate for contingencies, makes $53,000.

The light-house establishment maintains a sixth-order light, and the Life-Saving Service a station on the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven.

Appropriations for improving harbor at Pentwater, Mich.

March 2, 1867	$55,000	June 14, 1880	$4,000
April 10, 1869	17,820	March 3, 1881	10,000
July 11, 1870	10,000	August 2, 1882	10,000
March 3, 1871	10,000	July 5, 1884	15,000
June 10, 1872	30,000	August 5, 1886	10,000
March 3, 1873	20,000	August 11, 1888	8,000
August 14, 1876	10,000	September 19, 1890	8,000
June 18, 1878	10,000		
March 3, 1879	6,000	Total	233,820

Original estimated cost of the work, 1866, amended in 1873, 1884, and 1892	$286,820.00*
Whole amount appropriated from 1866 to and including act of September 19, 1890	233,820.00
Whole amount expended to June 30, 1892	231,393.89

Money statement.

July 1, 1891, balance unexpended	$7,818.19
June 30, 1892, amount expended during fiscal year	5,392.08
July 1, 1892, balance unexpended	2,426.11
July 1, 1892, outstanding liabilities	10.00
July 1, 1892, balance available	2,416.11
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	7,416.11
Amount (estimated) required for completion of existing project	24,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	48,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, PENTWATER HARBOR, MICHIGAN.

Entrances and clearances.

Year.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	461	$400.99	.....
1885	187	69.17	.....
1886	(*)	(*)	.....
1887	(*)	(*)	.....
Calendar year:			
1888	300	.....	45,000
1889	(*)	(*)	.....
1890	27	.....	2,559
1891	1,140	.....	71,260

* Not stated.

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*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Beer ..... tons..	.....	100	Brick ..... number..	600,000	1,200
Coal ..... do....	.....	115	Carriages	30	10
Furniture ..... do....	.....	18	Fruit and vegetables ... tons..	.....	550
Gravel ..... do....	.....	300	Fish ..... do....	.....	15
Grain ..... bushels..	14,851	342	Flour ..... barrels..	721	72
Hay and feed ..... tons..	.....	342	Furniture ..... tons..	.....	535
Iron ..... do....	.....	60	Lath	905,000	272
Lumber ..... M feet, B. M..	1,000	2,000	Live stock ..... head..	6	3
Live stock ..... head..	34	17	Lumber ..... feet, B. M..	5,887	11,774
Lime and cement ..... barrels..	500	50	Merchandise ..... tons..	.....	41
Machinery ..... tons..	.....	45	Posts ..... number..	45,217	1,130
Merchandise ..... do....	.....	566	Shingles	11,252	1,687
Salt ..... barrels..	965	144	Ties ..... number..	12,500	1,125
Stone ..... cords..	90	570	Wood ..... cords..	250	500
Total	.....	4,669	Total	.....	18,914

* Compiled from statement furnished by D. C. Wickham, of Pentwater, Mich.

K K 8.

IMPROVEMENT OF WHITE RIVER (LAKE) HARBOR, MICHIGAN.

The present project is for a 12-foot navigation 200 feet wide, and protected by piers and revetments, between Lake Michigan and White Lake.

The north pier is a pile structure filled with edgings and stone, 1,515 feet long, and projecting about 350 feet beyond the present shore line.

The south pier consists of 356 feet of crib work at its outer end, and of 1,498 feet of pile pier and revetment. It projects about 630 feet beyond the present shore line.

Although the project contemplates a channel with a navigable depth of 12 feet, it has not been possible to attain this object, except for short periods of time by means of repeated dredging, for the reason that the piers are not sufficiently extended and the inshore revetments are not sand tight.

With reference to the existing project, the north pier still needs 250 feet and the south pier 200 feet of crib work to complete them.

The north pier at present reaches only to the 8-foot curve in the lake, and even after its completion will fall some 300 feet short of the 15-foot curve, while the south pier after the addition of the proposed 200 feet will probably be long enough for a considerable time to come. It is evident that large quantities of sand find their way into the channel from the North Beach around the end of north pier, and the latter should be extended as soon as possible. Although on general principles the extension of the north pier requires the first attention, the end of the south pier is in a somewhat unstable condition. The end crib is slowly but steadily sinking into the bottom, and at least one crib should be added to the pier at the first opportunity to hold the present work.

Considerable portions of both piers and revetments have been rebuilt above water during the last few years, but there still remains 316 linear feet of north revetment (Station 7+40 to 10+56) and 367 linear feet of the south-side pile work (Station 3+56 to 7+23) which are now

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22 years old, and require new superstructure and filling. The mentioned portion of north pier particularly is in urgent need of attention, as the superstructure timbers are nearly gone and the filling being washed out permits the sand from the rear to wash into the channel. Part of the south-side crib work also needs repairs very badly, especially the cribs (Station 2+55 to 3+05 and 0+50 to 1+00) which have lost part of their lake wall.

In order to make the pile structures as nearly sand tight as practicable, they must be sheet-piled along the rear, and material for this purpose is now on hand at the harbor. A special land driver was built last year for this kind of work, but as it was first needed at other harbors it could not be made available for this harbor until now.

Operations have now been begun and the work will be pushed as rapidly as circumstances will permit.

Soundings made March 21 showed an available depth of only 9 to 10 feet at the entrance over a distance of some 400 feet and it is intended to send one of the Government dredges to this harbor at the first opportunity.

A permanent bench mark was established on the doorsill, south side of the light-house, and connected by duplicate levels with the United States gauge. Its elevation is 20.83 feet above the zero. A series of accurate water-gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

The balance of $11,400, available July 1, will pay for the work, now under way, of sheet-piling part of the north and south pile structures, for building new superstructure on north revetment from Station 7+40 to 10+56 (316 linear feet), for repairing the south-side crib work, and for the dredging required this season.

The amount that can be profitably expended during the next year is: For building five new cribs on north pier, $23,750, and four new cribs on south pier (to complete the project), $24,000; for 367 linear feet new superstructure and filling on south pier, $3,670; for sheet-piling 1,000 additional feet of north and south revetments, $3,000; and for dredging, $3,000, which, with 10 per cent for contingencies, makes $63,000.

The Light-House Establishment maintains a fourth-order flashing coast light on the shore and a sixth-order harbor light on the south pier. The Life-Saving Service has a station on the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at White River, Mich.

March 2, 1867	$57,000	March 3, 1879	$7,500
April 10, 1869	44,550	June 14, 1880	5,000
July 10, 1870	20,000	March 3, 1881	7,500
March 3, 1871	20,000	August 2, 1882	12,000
June 10, 1872	10,000	July 5, 1884	10,000
March 3, 1873	7,000	August 5, 1886	10,000
June 23, 1874	10,000	August 11, 1888	10,000
March 3, 1875	10,000	September 19, 1890	17,000
August 14, 1876	5,000		
June 18, 1878	12,000	Total	274,550

Original estimated cost of work, 1866, amended in 1873, 1884, and 1892	$337,550.00
Whole amount appropriated, 1866, to and including act of September 19, 1890	274,550.00
Whole amount expended to June 30, 1892	262,914.18

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Money statement.

July 1, 1891, balance unexpended	$18,117.94
June 30, 1892, amount expended during fiscal year	6,482.12
July 1, 1892, balance unexpended	11,635.82
July 1, 1892, outstanding liabilities	195.92
July 1, 1892, balance available	11,439.90
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	16,439.90
Amount (estimated) required for completion of existing project	43,225.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	58,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, WHITE RIVER HARBOR, MICHIGAN.

Entrances and clearances.

Year.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	304	$1,347.23	.....
1885	1,416	476.16	.....
1886	1,623	313.65	.....
1887	1,885	.....	262,440
1888	1,742	.....	184,247
Calendar year:			
1888	1,408	.....	147,142
1889	732	.....	.....
1890	579	.....	62,276
1891	405	.....	47,135

*Receipts and shipments by vessels, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Coal ..... tons	.....	82	Hay ..... tons	.....	20
Feed ..... do	.....	127	Lumber ..... feet, B. M.	20,395	35,691
Grain ..... bushels	21,346	587	Lath	350,000	105
Hay ..... tons	.....	5	Slabs ..... cords	7,119	19,136
Lime ..... barrels	116	13	Ties ..... number	17,000	1,530
Merchandise ..... tons	.....	148	Wood and bark ..... cords	735	919
Oil ..... barrels	10	2			
Wood and bark ..... cords	205	256			
Vinegar ..... barrels	20	2			
	.....	1,222		.....	57,401

*Compiled from statement furnished by the collector of customs.

K K 9.

IMPROVEMENT OF MUSKEGON HARBOR, MICHIGAN.

The official project adopted in 1866 and amended in 1880 and 1889, and again revised in 1892, provides for a navigation 15 feet deep, between piers 300 feet apart at the entrance and about 180 feet at the shore line.

January 25, 1892, a special report was submitted to the Chief of En-

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gineers, setting forth the condition and needs of the harbor, and showing with detailed estimates measures required for the construction and maintenance of a reliable 15-foot navigation. The report estimates for an extension of both piers 800 feet to reach the 20 foot contour in the lake; for dredging from lake to lake, with channel width of 75 feet and depth of 18 feet, and for revetting both banks from the inner end of the pier to Muskegon Lake. The total estimate for this work is $260,000, and recommendation was made for appropriation of $150,000 to cover two seasons' work. A copy of this report is herewith for incorporation.

The north pier, as now existing, consists of 800 linear feet of crib work, parallel with and distant from south pier 300 feet; of 329.6 linear feet of crib work built in 1891–'92, connecting the outer portion of the pier at an angle with the interior portion, in order to close the long-existing gap in the north pier; of 322 linear feet of old crib work and 392 linear feet of pile work parallel with the south pier, at a distance of 180 feet. It projects about 900 feet beyond the present shore line. The former end crib, which had been undermined and torn apart from the rest of the work in 1889, has been removed and is now under contract to be replaced, together with one additional crib, which it has been considered necessary to add in order to insure the stability of the restored old crib.

The south pier consists of 800 linear feet of crib work and 380 linear feet of pile work, and projects about 920 feet beyond the present shore line.

Both piers are in good condition, with the exception of the inner 322 feet of the north-side crib work, which is now from 22 to 24 years old, and needs rebuilding above the water line, and the north-side pile work, which is somewhat unstable, in consequence of undermining, and needs an additional row of piles along the channel wall and other minor repairs. Besides, there is some additional stone needed to refill the crib work and to riprap the end of the south pier.

From the inner end of the Government works to Muskegon Lake the channel banks are partly revetted with slabs. This work was done in former years by the occupants of the shore, but since the lumber mills have been removed they have received no care and are now fast breaking down. The project includes the substitution of new sheet pile revetments for the old slab docks, and the material for 1,000 linear feet of this work for the north side is now on hand.

Contractor E. G. Crosby completed the removal of 316 linear feet of the inner north pier and the construction of the new crib work to close the gap between the remaining portion of the old pier and the north detached pier in October, 1891. The removal of the old pier was effected by blasting it out with dynamite and dredging up the débris. All the old stone filling was saved and afterwards used again in the new crib work. The latter consists of seven cribs, 20 feet wide, the end cribs being framed to form close joints with the adjacent structures, which they connect. The cribs rest on a pile foundation, and with the superstructure are 20½ feet high.

The total length of the new work is 329.6 feet on the channel side, 2 feet of which overlap the horns of the former detached piers. At both ends it is securely connected with the old structures. It is filled with stone to the top and decked over.

Gaylord & Wing, the contractors for the raising and restoration of the outer sunken crib of the north pier, having commenced actual operations June 29, continued their work under considerable difficulties. They removed the stone filling by means of divers, and at the

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end of September had so far completed that portion of the undertaking as to feel justified in attempting to raise the crib with chains and jack-screws, rigged up on a specially constructed platform of piles and timber. The long exposure of the crib to the effects of the frequent and severe storms of the season had weakened it, however, to such degree that it failed to withstand the strain and tore apart just above the grillage bottom. The two parts were then raised separately, towed to a safe anchorage in Muskegon Lake, and left for the winter.

The stone removed from the crib by the contractors measured 153 cords, 72 cords of which were placed in the old work as filling, which is badly needed, the remaining 81 cords being stored on top of the pier for future use in filling the restored crib. The 72 cords placed in the old work will be replaced by the contractors at their own cost. They were permitted to deposit it in the pier at their request, as it hindered them in their operations, and were in consequence willing to replace it at $5 per cord, which is a much lower price than that at which that material can be bought here under ordinary circumstances. As there was no possibility of their completing the work within the time specified by the contract, the contractors requested an extension to August 1, 1892, and this was granted by the Chief of Engineers.

The improbability of the contractors completing the work on the old crib before August 1, 1892, and the impracticability of having other contractors carry on operations at the end of the pier at the same time, subsequently led to a recommendation to the Chief of Engineers to enlarge the Gaylord & Wing contract for restoration, by adding to it that for the construction of the additional crib to be placed outside of the restored old one, and also to modify the first contract in so far as related to the stone foundation, later developments showing that it would be entirely practicable to replace the old crib on a pile foundation and insure more uniform work. This recommendation received the approval of the Chief of Engineers, and a supplementary contract embodying these provisions was concluded with Gaylord & Wing March 25, 1892, the work to be completed September 1, 1892.

The contractors resumed operations under the modified contract May 12. The upper part of the old crib was cut up, saving only the uninjured cross-ties and the iron for use in the reconstructed crib. A new center sill was placed under the recovered lower portion, which was otherwise restored by new timber blocking and bolting to a sound and satisfactory condition, and the crib entirely rebuilt from the third course up with the suitable old and otherwise with new material. At the close of the fiscal year the structure had been completed to the twelfth course.

The construction of the new crib has progressed to include the twentieth course, which makes the crib ready for sinking in its place when the pile foundation shall have been prepared.

At the beginning of the fiscal year the navigable depth in the harbor was from 15 to 16 feet at the entrance and between the piers. Soon after the closing of the gap in the north pier this commenced to show its effect on the entrance channel. The former gap had acted as a sort of sluiceway, the large body of water pouring through under the influence of northerly gales assisting by its scouring effect in maintaining a certain navigable depth in the outer portion of the fairway. The purpose of the closing structure, namely, the removal of the dangerous cross currents at the entrance, had been fully attained, but the channel shoaled perceptibly. At the end of September the 15-foot depth had narrowed to 70 feet next to the south pier, and the remainder of the

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space between the piers was occupied by a shoal with only 11 feet water over it.

In order, if practicable, to restore the needed depth of water, and at the earnest solicitation of the harbor interests, the Government dredge *Farquhar* commenced work October 9, but the season was so rough that to November 30 but eleven days were partially fit for dredging, and but four of these at the end of the pier. The benefit of this dredging to the harbor was consequently very slight, and the cost per yard very heavy, viz, 33 cents. Five thousand nine hundred and ten cubic yards was the quantity removed during the seven and a half weeks that the dredge was kept in commission.

This endeavor to relieve navigation near the end of the pier and so late in the season was undertaken and continued with two objects in view: First. The attainment, if by chance it were possible, of the desired result, as to which, however, no favorable expectations whatever were entertained. Second. To prove conclusively the practical difficulties and outlay involved in such an attempt, and thereby meet with facts, in lieu of arguments, the insistance on the part of those interested, both at Muskegon and at several other points, that the Government dredge be kept under pay for the work in question. The demonstration was convincing and worth what it cost to make it.

At the opening of navigation in 1892 great difficulty was immediately experienced by entering and departing vessels; a number of vessels grounded in the shoal water and were with difficulty released. There was a depth of scant 12½ feet close to the south pier.

The Government dredge *Saginaw* began work April 21, dug a channel 100 feet wide and 18 feet deep at the entrance, and removed the shoal places in the inside navigation to Muskegon Lake to a depth of 16 feet, completing this work May 31. The quantity of material removed was 30,914 cubic yards.

On May 5 the *Saginaw*, while at work at the harbor entrance with the spuds down, was run into by the *City of Racine*, breaking two spuds. The dredge was delayed four days making repairs.

A permanent bench mark was established on top of the stone sill of the most southerly window on the east side of the light-house. Its elevation is 9.43 feet above zero of gauge. A series of accurate water-gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of procuring data for the adjustment of the zero of the gauge to a uniform level with the gauges at the other harbors.

Upon completion of the work now under contract both piers will lack 800 feet of their full extension according to the revision of January, 1892.

The recommendations for the fiscal year 1894 are: For 322 linear feet new superstructure, north pier, Stations 3 + 16 to 6 + 38, $3,220; for repairing north pile pier and revetment, $700; for refilling both piers and riprapping end of south pier, $1,500; for building 1,000 linear feet sheet-pile revetment, north side (timber and piles on hand), $2,000; for 2,000 additional feet sheet-pile revetment (1,000 on each side), $12,000; for ten new cribs on the north pier and ten on the south pier, $120,000, and for dredging, $4,000, which, with 9 per cent for contingencies, makes $156,000.

The Light-House Establishment maintains a fourth-order coast light on the south shore and a sixth-order harbor light on the south pier. The Life-Saving Service has a station on the north pier

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

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Appropriations for improving harbor at Muskegon, Mich.

March 2, 1867	$59,000	March 3, 1881	$20,000
July 11, 1870	10,000	August 2, 1882	25,000
March 3, 1871	15,000	July 5, 1884	20,000
June 10, 1872	10,000	August 5, 1886	12,500
June 23, 1874	10,000	August 11, 1888	45,000
March 3, 1875	25,000	September 19, 1890	50,000
August 14, 1876	15,000		
March 3, 1879	5,000	Total	329,000
June 14, 1880	7,500		

Original estimated cost of the work, 1866, amended in 1869, 1873, 1881, 1884, 1890, and 1892	$589,000.00
Whole amount appropriated from 1866 to and including act of September 19, 1890	329,000.00
Whole amount expended to June 30, 1892	317,796.53

Money statement.

July 1, 1891, balance unexpended		$44,727.79
June 30, 1892, amount expended during fiscal year		33,524.32
July 1, 1892, balance unexpended		11,203.47
July 1, 1892, outstanding liabilities	$311.23	
July 1, 1892, amount covered by uncompleted contracts	9,640.39	
		9,951.62
July 1, 1892, balance available		1,251.85
Amount appropriated by act approved July 13, 1892		75,000.00
Amount available for fiscal year ending June 30, 1893		76,251.85
Amount that can be profitably be expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		156,000.00

COMMERCIAL STATISTICS, MUSKEGON HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	7,160	$4,987.06	.....
1885	6,112	1,621.34	.....
1886	5,543	1,025.17	.....
1887	1,745	.....	232,007
Calendar year:			
1888	2,685	.....	.....
1889	4,626	.....	884,869
1890	3,786	.....	649,540
1891	2,886	.....	704,046

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Receipts and shipments by vessel, 1891. *

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Cement ..... tons..	.....	14	Crackers ..... barrels..	300	10
Coffee ..... sacks..	272	26	Fish ..... do....	560	62
Fruit ..... boxes..	7,599	304	Flour ..... do....	1,170	117
Flour ..... sacks..	9,515	476	Fruit and vegetables .. tons..	.....	140
Furniture ..... packages..	870	36	Furniture ..... packages..	34,221	1,510
Groceries ..... do....	8,580	1,287	Iron ..... tons..	.....	8,017
Grain ..... bushels..	107,454	2,955	Lath ..... M..	13,747	4,124
Gravel ..... cubic yards..	188	234	Lumber ..... M feet, B. M..	274,986	481,225
Iron ..... tons..	.....	1,877	Merchandise .. .. tons..	.....	209,270
Lime ..... barrels..	1,995	219	Paper ..... do....	.....	4,000
Meats ..... boxes..	682	102	Plaster ..... barrels..	5,738	861
Merchandise ..... tons..	.....	2,238	Staves ..... packages..	11,100	250
Oil ..... barrels..	325	65	Sundries ..... do....	34,641	1,732
Pickets	450,000	788	Sugar ..... barrels..	21	5
Soap ..... boxes..	375	14	Sawdust ..... tons..	.....	1,446
Stone ..... cords..	8,110	50,688	Shingles ..... M..	9,463	1,183
Sundries ..... packages..	43,947	2,197	Slabs ..... cords..	152,000	408,576
Sugar ..... barrels..	3,050	763	Wood ..... do....	596	894
Tar ..... do....	225	68	Wheelbarrows ..... number..	580	73
Vinegar ..... do....	385	39			
Lumber ..... M feet, B. M..	6,645	11,628	Total	.....	1,123,495
Total	.....	76,018			

* Compiled from statement furnished by the Board of Trade of Muskegon.

REPORT OF MAJOR WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 25, 1892.

GENERAL: Pursuant to telegraphic instructions of January 22, I beg to report as follows relative to the present condition of Muskegon Harbor, Michigan, and to what is required for its improvement. The accompanying blue prints show the condition of the harbor at the respective dates of examination, viz, September, 1890, and November, 1891. From the depths as shown on the tracing are to be deducted the variation of the lake surface below the harbor zero, constituting the corrections for reduction, which vary 6 inches to 2 feet on the 1890 map and 1.7 on the 1891 map. As appears to be the case almost invariably, at this harbor a 15-foot bar exists outside the piers, and this depth is reduced at times by an abnormal wave action during heavy gales in fall and spring. The navigation depth is thus diminished at times to 11 feet, and the entrance becomes unsafe or impracticable for laden vessels of the ordinary lake drafts. The official project for Muskegon Harbor provides for an actual navigation of 13 feet, but it is evident that to secure this reliably three points must be covered.

(1) The piers should have such extension into the lake as to cover the entrance to such depth beyond the actual navigable depth as to protect the channel when made, and to allow for the rise and fall of the sea and the send of a heavy vessel. This would indicate that the pier should reach at least the 20-foot contour in order to be sure of having 15 feet clear between them.

(2) The fairway between the piers, and thence upward, should be dredged to a depth sufficient to allow for reduction of lake level below the zero plane, and for the inevitable filling in of the dredged channel which follows disturbance of the bottom and ensues from the breaking down of the channel walls and the readjustment of the bottom materials.

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This indicates dredging to, say, 18 feet in order to be sure of securing 15 or 16 feet.

(3) In order to prevent as far as may be the access of loose material from the banks, these must be revetted throughout the length of the dredged channel of entrance, as the action of currents, of waves, of wind, and of passing vessels tends constantly to the erosion of the channel banks, the seepage of sand into the channel, and its delivery in the fairway.

A complete statement of what is required for the thorough improvement of Muskegon Harbor, in order that its navigation may be fully and properly adapted to the commercial requirements, must include three items:

(1) Pier extension in such measure as is needful to create and protect a clear 15-foot navigation. This, for the present, is assumed at about 20 feet, although it is by no means certain that ultimately the 25-foot contour in the lake should not be reached.

(2) The dredging of the channel or fairway from lake to lake to a depth, say, of 18 feet, with a width of 75 feet.

(3) The revetment of both banks, whenever unprotected, with as economical a structure as will be substantial. For this purpose the following estimates are made:

(1) Pier extension. To enable both piers to reach the 20-foot contour in the lake an extension of 800 feet is required for both. Estimating the cost of this work from the most recent and reliable data for similar conditions, the cost per linear foot will average $120.

(2) To dredge a channel 75 feet wide and 18 feet deep from lake to lake requires the handling of 54,000 cubic yards, which under contract will cost say 15 cents per cubic yard.

(3) The revetting of the naked banks involves covering some 5,600 linear feet on the two banks, and the structure proposed for this will cost $6 per linear foot. The total estimate therefore is as follows:

1,600 linear feet pier, at $120	$192,000
5,400 cubic yards dredging, at 15 cents	8,100
5,600 linear feet revetment, at $6	33,600
Total	233,700
Contingencies, 11 per cent	26,300
Aggregate	260,000

The funds in hand will suffice to build a single crib on the north pier outside of the damaged crib, which is under contract of restoration, and the total pier extension above noted of 800 feet on each pier is computed from what would be the outer ends of the two piers, supposing the work now under way and immediately in prospect to have been completed. There are at this time the materials for about 1,000 linear feet of revetment on the north pier under contract, and we have funds enough to build it. The present revetment estimate, therefore, omits this from consideration. The dredging estimate is computed on the basis of the most recent survey.

The estimate of $50,000 given in the annual report 1891, as the basis for appropriations for the fiscal year 1892, was intended to cover 300 feet extension of pier, half on each side; 2,000 linear feet of revetment, half on each side, with an allowance for dredging and contingencies.

Under the system of biennial appropriations for rivers and harbors which has prevailed of late years, the appropriations to be made at this session of Congress must do duty for two years. In the case of Muskegon, a fair season's work would be about as follows: Say 10 cribs for

pier extension, five on each side, 2,800 feet of revetment, and all the dredging, the cost of which in all would be, with contingencies, etc., $80,000.

During the following season, the remaining half of the revetment would be built, and say, 12 more cribs, which, with some allowance for dredging and contingencies, would cost say $96,000, leaving the remaining ten cribs to be added later. If, therefore, the improvement of the harbor were to be planned and prosecuted as an engineering measure without reference to the system of scaling annual appropriations, so as to prolong the work and maintain it in an unfinished condition, a favorable method of appropriating would be the allotment of the sum required for the season of 1893 and 1894, namely $176,000.

It is not to be expected that an appropriation of this amount can be had at one time, but it is evident from the data furnished that an appropriation of $150,000 could be advantageously expended in the ensuing two years.

In explanation of the commercial conditions expending upon free access to the harbor of Muskegon, I can hardly do better than refer to my annual reports of 1890 and 1891, copies of which are herewith.

Respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers, etc.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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IMPROVEMENT OF GRAND HAVEN HARBOR, MICHIGAN.

The existing project, adopted in 1866, and amended in 1880 and 1890, is to secure an entrance channel 18 feet deep between piers and revetments 400 feet apart.

The present constructions are as follows:

On the north side 1,059 linear feet of crib work and 2,128 linear feet of pile pier and revetment, or a total of 3,187 linear feet, projecting 1,200 feet beyond the present shore line.

On the south side 1,205 linear feet of crib work and 4,272 linear feet of pile pier and revetment, a total of 5,477 linear feet, projecting 1,420 feet beyond the present shore line.

No difficulty was experienced during the past year by entering and departing vessels, the available depth never having been less than 15.5 feet between the piers, and 17 to 18 feet on the crossing of the outer bar, and the steamers of the Detroit, Grand Haven, and Milwaukee Railway made regular trips throughout the winter.

The construction of 6 new cribs, 3 on each pier, commenced during the previous fiscal year, under contract with E. G. Crosby, was completed in October, 1891. The cribs are each 50 feet long and 30 feet wide, and with the superstructure about 27 feet high in the north pier and about 29 feet high in the south pier. Each crib rests on a foundation of 39 piles, the piles penetrating from 13 to 15 feet in the ground. The work was filled with stone to the top and decked over. A mooring post was built into each crib. The foundation piling of the new cribs

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was examined by a diver and found to be satisfactory, with a few slight exceptions, which were remedied by driving three additional piles and securing them under the cribs, to assist the same number of original piles, which had been found to project with part of their diameter outside.

The lake bottom, which at the crib site had been 22 to 23 feet below the zero of gauge previous to placing the cribs, scoured out afterwards to a depth of 27 to 28 feet at the outer end of the south pier, but no apprehensions were entertained, as this was the greatest depth of which there was any record, and the foundation piles, which are twelve more in number under each crib than those under any crib placed heretofore, still had a penetration of about 10 feet. However, the great storm of December 4 and 5 threatened destruction to the new work. Report of this under date of February 18, 1892, is herewith. This gale which blew continously from thesouthwest with a maximum velocity of 51 miles on the 4th and 49 miles on the 5th created a head of water in the angle between the south pier and the beach, causing a powerful offshore current along the lake wall of the south pier and around its outer end and scouring out the bottom to the unprecedented depth of 38 feet below zero of gauge, undermining the foundation piles and letting the cribs sink down. Measurements made after the cessation of the storm showed that the amount of subsidence at the outer end was 11 feet, while a lateral displacement had taken place at the same time, towards the south, to the extent of 11 feet at the lake end.

The superstructure timbers had been torn apart, there being gaps of 4 feet in the second crib from the end, and smaller ones at other places.

The stone filling does not appear to have moved much at first. On December 6 a noticeable settling was apparent only in one pocket of each of the two outer cribs, both on the lake side, although a subsequent diver's examination disclosed large holes under the cribs. On December 14, one pocket of the outer crib had lost all its stone, two pockets in the second crib were half empty, and nearly the whole lake side half of the three new cribs had experienced a perceptible settlement of its filling, while the filling along the channel side underwent almost no change.

The piles under the end crib, where the diver found the bottom accessible, had disappeared.

Steps were immediately taken to strengthen the work temporarily, so as to hold it till spring, when permanent repairs were to be made, and the pier secured by the addition of new crib work. Extra timbers were screw-bolted over the gaps in the superstructure, long drift bolts reaching down into the cribs proper were driven through the superstructure timbers, and a large quantity of stone was cast around the two outer cribs. About 40 cords of stone were borrowed from St. Joseph Harbor, where it was in store without immediate call for its use, and the rest, about 80 cords, was taken from the inshore revetments. The empty pocket of crib 3 and the corner pockets of crib 2 were refilled with part of this stone. Since the beginning of January no further change in elevation or alignment has been noticed.

The circumstances attending the accident to the crib work indicated several defects in the general design of the cribs heretofore built, and a modified design was prepared for future use. The new plan provides for a closed central compartment, of nearly half the total capacity of the crib, to hold the permanent load, and a narrower compartment on each side, next to the side walls, with open bottoms to

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permit the filling to pass through and protect the lake bottom in the case of a scour under the crib, and to insure a continuous wall of stone from the lake bottom up to the top of the work. The foundation piles are arranged in four rows, instead of three, as heretofore.

In April, 1892, a contract was concluded with Truman & Cooper for the construction of a 100-foot crib on the new plan, to be placed in extension of the south pier, and for the delivery of the required timber and stone to repair the sunken portion of the pier. The construction of the new crib was commenced by the contractors on May 25, and at the end of the fiscal year twenty courses had been completed.

Repairs by day labor were made to the south revetment by strengthening the work with iron tie rods passing through both walls and by patching up the timber work where broken by collisions or decay, and 600 feet of the north pile pier were refilled along the channel wall with new brush and old stone. Three hundred linear feet of additional sand fence were built on the north and south beach.

The sunken end of the south pier has been rebuilt to its original elevation, preparatory to making proper connection with the new crib, and partly refilled with stone.

Part of the material for the proposed 1,500 linear feet of sheet pile revetment for the extension of the north revetment has been received, but construction will have to be delayed till after the passage of next appropriation.

The Government tug *Williams* and the scow *Samson* received needed repairs to fit them for the season's work.

A permanent bench mark was established on top of water table at northwest corner of the Kirby House, and connected by duplicate levels with the automatic water gauge. Its elevation is 14.54 feet above the zero of the gauge.

The condition of the present works and their requirements are as follows:

North pier.—This work is in good condition throughout, with the exception of some needed refilling of about 1,000 linear feet of revetment from the life-saving station east, the closing of an open interval near Station 6, the refilling of the three outer cribs, and some stone riprap around the end of the pier.

South pier.—After the completion of the repairs now under way, of the end of the pier, this work will be in good condition for some time to come, with the exception of 667 linear feet of the south revetment from Stations 11+67 to 18+34, and 1,633 feet of revetment from Stations 30+35 to 46+68. The first-mentioned part was built in 1871 and 1872, and has received no repairs since that time, except some trifling patchwork. The second part was constructed in 1882, and is therefore comparatively new, but its peculiar location in the bend of Grand River, where it is constantly exposed to glancing blows from passing vessels, and the great depth of water in which it is built, furnish the explanation for its early decay. Both parts should be rebuilt above the water surface, and the part from Stations 30+35 to 46+68 should be additionally strengthened with extra pile in the rear wall.

The Annual Reports for 1890, pages 2648, 2652, and 1891, pages 2692, 2693, dwell at length on the necessity of the further protection of the north bank of the river to prevent erosion, and of additional means to control the moving sands of the high dunes north of the harbor. The recommendations made in this respect are renewed.

To complete the present project the north pier still needs an exten-

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sion of 500 linear feet and the south pier of 300 linear feet beyond that now under contract. The changes made necessary in the general plan of cribs and foundation, to prevent a recurrence of the dangers like that of last winter, inevitably enhance the cost of the work, and the new cribs in view of their location far out in the lake can not be built for the sum considered sufficient heretofore.

The estimate for the fiscal year 1894 is therefore as follows: 800 linear feet crib work to extend both piers and complete the project, $112,000; 2,500 linear feet of shore revetment, $15,000; sand fencing, shrub planting, etc., $7,000; 2,300 linear feet repairs of south revetment, $18,400; general repairs of existing works, $5,000; dredging $5,000, which, with contingencies, makes $180,000.

The Light-House Establishment maintains a fourth-order flashing coast light south of the entrance and a sixth-order light on the south pier, with duplicate fog signals.

The Life-Saving Service has a station on the north pier, inside the shore line.

This harbor is included in the Michigan collection district, Michigan. Grand Haven is a port of entry.

Appropriations for improving harbor at Grand Haven, Mich.

August 30, 1852 (mouth of Grand River)	$2,000.00	August 14, 1876	$15,000.00
March 2, 1867 (mouth of Grand River)	40,000.00	June 18, 1878	15,000.00
June 23, 1866	65,000.00	March 3, 1879	9,000.00
April 10, 1869	1,866.15	June 14, 1880	50,000.00
July 11, 1870	10,000.00	March 3, 1881	50,000.00
1870 (allotment)	500.00	August 2, 1882	40,000.00
March 3, 1871	6,000.00	July 5, 1884	50,000.00
June 10, 1872	15,000.00	August 5, 1886	30,000.00
March 3, 1873	75,000.00	August 11, 1888	25,000.00
June 23, 1874	50,000.00	September 19, 1890	75,000.00
		Total	624,366.15

Original estimated cost of the work, 1866, amended in 1880, 1890, and 1892	$804,366.15
Whole amount appropriated and allotted from 1852 to and including act of September 19, 1890	624,366,15
Whole amount expended to June 30, 1892	604,240.82

Money statement.

July 1, 1891, balance unexpended		$58,422.18
June 30, 1892, amount expended during fiscal year		38,296.85
July 1, 1892, balance unexpended		20,125.33
July 1, 1892, outstanding liabilities	$628.59	
July 1, 1892, amount covered by uncompleted contracts	14,058.14	
		14,686.73
July 1, 1892, balance available		5,438.60
Amount appropriated by act approved July 13, 1892		90,000.00
Amount available for fiscal year ending June 30, 1893		95,438.60

Amount (estimated) required for completion of existing project	35,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	90,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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Abstract of proposals for extension and repair of South Pier, at Grand Haven Harbor, received and opened March 15, 1892, by Maj. William Ludlow, Corps of Engineers.

Name and address of bidder.	Foundation piles, (761, 508 linear feet).		Guard piles, 13 (702 linear feet).		Hemlock timber (17,624 feet, B. M.).		Pine timber (84,344 feet, B. M.).		Oak timber (936 feet, B. M.).	
	Per linear foot.	Amount.	Per linear foot.	Amount.	Per M feet, B. M.	Amount.	Per M feet, B. M.	Amount.	Per M feet, B. M.	Amount.
D. A. McLeod, Manistee, Mich.	$0.90	$1,357.20	$0.40	$280.80	$17.50	$2,895.92	$24.00	$2,024.26	$40	$37.44
Edward G. Crosby, Muskegon, Mich	.95	1,432.60	.40	280.80	18.50	3,156.54	26.00	2,192.94	40	37.44
Knapp & Gillen, Racine, Wis	.90	1,357.20	.25	175.50	18.00	3,071.23	25.00	2,108.60	40	37.44
McDonell Bros. & Co., Grand Rapids	.90	1,357.20	.40	280.80	18.50	3,156.54	24.00	2,024.26	40	37.44
C. E. Mitchell & Co., Ludington, Mich	1.00	1,508.00	.25	175.50	22.00	3,753.73	27.00	2,277.29	40	37.44
Joseph A. Beauvais, Charlevoix, Mich	2.00	3,016.00	2.00	1,404.00	24.00	4,094.98	32.00	2,699.01	45	42.12
Weimer & Rath, Ludington, Mich	1.25	1,885.00	.50	351.00	20.00	3,412.48	27.25	2,298.37	55	51.48
Truman & Cooper, Manitowoc, Wis	.50	754.00	.20	140.40	17.50	2,985.92	23.25	1,961.00	40	37.44
Crouter & Burns, Charlevoix, Mich	.95	1,432.60	.50	351.00	18.00	3,071.23	24.00	2,024.20	40	37.44

Name and addaess of bidder.	Pine plank, (7,000 feet, B. M.).		S. and W. bolts (3,099 pounds).		Drift bolts (31,798 pounds).		Wrought spikes (428 pounds).		Stone in work (695 cords).		Dredging for foundation (300 cubic yards).		
	Per M feet, B. M.	Amount.	Per pound.	Amount.	Per pound.	Amount.	Per pound.	Amount.	Per cord.	Amount.	Per cubic yard.	Amount.	Total.
			Cts.		*Cts.*		*Cts.*						
D. A. McLeod, Manistee, Mich.	$18	$126	3.5	$108.46	3	$953.94	3	$12.84	$7.50	$5,212.50	$0.50	$150.00	$13,249.36
Edward G. Crosby, Muskegon, Mich	20	140	5	154.95	3.5	1,112.93	5	21.40	6.75	4,691.25	.03	9.00	13,229.85
Knapp & Gillen, Racine, Wis	19	133	4	123.96	3	953.94	4	17.12	7.25	5,038.75	.05	15.00	13,031.74
McDonell Bros. & Co., Grand Rapids	18	126	5	154.95	4	1,271.92	5	21.40	7.40	5,143.00	.50	150.00	13,723.51
C. E. Mitchell & Co., Ludington, Mich	22	154	5	154.95	4	1,271.92	5	21.40	9.00	6,255.00	.20	60.00	15,669.23
Joseph A. Beauvais, Charlevoix, Mich	30	210	9	278.91	6	1,907.88	8	34.24	13.00	9,035.00	2.00	600.00	23,322.14
Weimer & Rath, Ludington, Mich	24	168	5.75	178.19	4.5	1,430.91	5.5	23.54	7.75	5,386.25	.25	75.00	15,260.22
Truman & Cooper, Manitowoc, Wis	16	112	4	123.96	3	953.94	4	17.12	7.00	4,865.00	.20	60.00	12,010.78
Crouter & Burns, Charlevoix, Mich	18	126	5	154.95	4	1,271.92	5	21.40	9.00	6,255.00	.50	150.00	14,895.80

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Abstract of proposals for extension and repair of South Pier, etc.—Continued.

Name and address of bidder.	For repairs.				Total.
	White pine (16,992 feet. B. M.).		Stone in work (250 cords.)		
	Per M feet B. M.	Amount.	Per cord.	Amount.	
D. A. McLeod, Manistee, Mich	$20.00	$339.84	$8.00	$2,000.00	$2,339.84
Edward G. Crosby, Muskegon, Mich	26.00	441.79	6.75	1,687.50	2,129.29
Knapp & Gillen, Racine, Wis	30.00	500.76	7.25	1,812.50	2,322.26
McDonell Bros. & Co., Grand Rapids	18.00	305.86	7.40	1,850.00	2,155.86
C. E. Mitchell & Co., Ludington, Mich	19.00	322.85	9.00	2,250.00	2,572.85
Joseph A. Beauvais, Charlevoix, Mich	52.00	543.74	17.00	4,250.00	4,793.74
Weimer & Rath, Ludington, Mich	24.00	407.81	7.00	1,750.00	2,157.81
Truman & Cooper, Manitowoc, Wis	17.50	297.36	7.00	1,750.00	2,047.36
Crouter & Burns, Charlevoix, Mich	20.00	339.84	7.00	1,750.00	2,089.84

Contract awarded to Messrs. Truman & Cooper, and executed under date of April 1, 1892.

COMMERCIAL STATISTICS, GRAND HAVEN HARBOR, MICHIGAN.

Entrances and clearances.

Year.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	2,331	$5,221.81	.....
1885	1,634	1,985.43	.....
1886	1,384	1,548.32	.....
1887	1,297	.....	632,159
1888	1,888	.....	1,036,029
Calendar year:			
1888	1,508	.....	1,405,600
1889	1,110	.....	649,370
1890	1,172	.....	834,089
1891	819	.....	616,422

*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Beer ..... barrels	3,926	393	Beer ..... barrels	54	5
Cement ..... tons	.....	17,315	Cement ..... do	100	15
Feed ..... do	.....	5,657	Cheese ..... boxes	200	4
Fish ..... do	.....	134	Coal ..... tons	.....	1,658
Flour ..... barrels	725,355	72,535	Fruit ..... do	.....	960
Grain ..... bushels	15,888	437	Fish ..... barrels	330	36
Iron and ore ..... tons	.....	33,773	Gravel ..... tons	.....	3,250
Lard ..... tierces	5,951	982	Iron ..... do	.....	1,058
Leather ..... bundles	38,072	1,904	Lumber, M feet, B. M.	3,761	6,582
Lime ..... barrels	280	31	Leather ..... bundles	18,739	937
Lumber, M feet, B. M.	360	630	Lime and cement ..... tons	.....	49
Merchandise ..... tons	.....	7,223	Merchandise ..... do	.....	21,556
Malt ..... sacks	17,131	685	Paper stock ..... bales	1,291	65
Nails ..... kegs	772	39	Rags ..... do	31	7
Oil ..... barrels	60	12	Seeds ..... bushels	2,282	114
Pork ..... do	2,146	215	Staves ..... car loads	43	753
Rags ..... bales	1,734	390	Slabs ..... cords	1,643	4,416
Rubber, scrap ..... do	5,625	3,655			
Stone ..... cords	5,026	31,412	Total	.....	40,865
Seeds ..... sacks	2,282	114			
Tobacco ..... cases	831	8			
Wool ..... bales	3,319	290			
Vegetables ..... tons	.....	200			
Vinegar ..... barrels	4,752	475			
Total	.....	178,499			

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* Compiled from statements furnished by the collector of customs and by Col. R. C. Duryea.

REPORT OF MAJOR WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., February 18, 1892.

GENERAL: I have the honor to forward herewith plans and specifications and form of advertisement for the continuation of work on the Grand Haven Harbor, Michigan, with request for consideration and approval.

The steps in this direction would have been taken earlier had it not been for the damage to the outer three cribs of the south pier, to which reference was made in the monthly report for December. It has been necessary to keep these cribs under observation for a certain period in order to feel sure that the limit of movement had been reached before making arrangements for additional work. The storm of December 4 on Lake Michigan was of exceptional severity, and occasioned notable changes at nearly all the harbors on the east coast, the wind blowing heavily and continuously from the southwest, producing a very heavy sea at the entrance and setting in motion immense quantities of sand in the lake bed.

At Grand Haven, owing to the great projection of the pier into the lake, a formidable scouring action was developed, due to the piling up of the water in the angle between the south pier and the shore line, whence it escaped in a powerful current offshore along the pier and across its outer end northward.

The erosion adjacent to the pier amounted to from 5 feet at about 150 feet from the end to 10 feet at its extremity, in consequence of which the current cut under the three outer cribs, leaving the foundation piles exposed and letting the cribs down by the inability of the piles to support them.

It was at first feared that these three cribs, which were built last season and as well as any on the lake, were practically destroyed, but within two or three weeks after the storm the cribs seemed to reach their ultimate movement, the excess of depth adjacent to them was partly refilled, and observation by transit and level indicate that a permanent position has been reached.

Two results ensue:

(1) It had been proposed with the balance to the credit of the appropriation to continue construction by building four new cribs, two on each pier, but this balance must be drawn upon to rebuild the superstructure of the three damaged cribs, to restore the level and integrity of the work. It is estimated that these repairs will cost between $3,000 and $4,000, nearly the cost of one 50-foot crib.

The possibilities of construction at this time are therefore reduced to three cribs, two on one pier and one on the other. The construction of a single crib at the outer end of piers so exposed as at Grand Haven is inexpedient for the reason that the precautionary additions to an end crib to secure its safety until further extension can be made, cost about $800 in excess of that of an interior crib, and this expense is wasted so soon as additions to the pier are made. As it may be expected that further appropriations will presently be made for Grand Haven, it is therefore deemed advisable to defer the single outer crib for the north pier and limit the construction at this time to the addition of two cribs to the south pier.

It does not appear advisable to build three new cribs on the south pier, because the history of the harbor indicates that the mean action of winds and waves at this harbor is nearly normal to the shore line, and

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that the resultant action is directly shoreward and that the best results to navigation have been found when the outer ends of the two piers are kept nearly abreast of each other.

(2) Pile foundations have in general been used for the eastern Lake Michigan harbors with good results but with occasional failure, as formerly at Muskegon and Michigan City and recently at Grand Haven. On the other hand, the riprap foundation used elsewhere on the lake in some cases, as at Chicago, with satisfactory results, when tried two seasons ago at Michigan City in connection with the outer breakwater was not satisfactory, the weight of the cribs, etc., forcing the riprap 5 and 6 feet into the lake bed, and requiring subsequent raising on two occasions. Furthermore, after two years of settlement, a hard northerly storm, at Michigan City last fall, was still found to affect the line and level of the work. The recent experience with the Grand Haven cribs has proved conclusively that at so great a projection into the lake, exposed to powerful currents and seas, a pile foundation alone is not reliable, while the Michigan City experience indicates that a riprap foundation requires for ultimate rest an undue and uncertain period of time.

It is, therefore, necessary in the Grand Haven case to combine the two methods, and, for the attainment of a reliable level as well as security of construction, to use a foundation of piles driven to proper depth and to strengthen these and prevent erosion of the lake bed by a free use of riprap.

The accompanying plans and specifications provide for these and for another point in addition. If 100 linear feet of pier are to be built there does not seem to be any sound reason for not building a single crib 100 feet long instead of two cribs of 50 feet each.

The advantage of the single structure in point of strength being continuous at every course from the bottom up instead of being entirely separated below the superstructure would seem obvious, and there should be some economy also perhaps.

It is true that an attempt some years ago at one of the western harbors to sink a 100-foot crib was not entirely fortunate, but this, it is believed, was due to insufficient means of loading the crib promptly, the stone scows being of small dimensions. The stone scows now in use on the lake are of large dimensions, capable of carrying 150 to 200 cords of stone, and the specifications provide that the crib shall be half filled within twelve hours and entirely so within twenty-four. There is no reason to anticipate any difficulty in this direction, and none that will offset the advantages of the single construction, which, it is believed, will in the present case be found entirely advantageous.

It is therefore proposed to contract for a 100-foot crib, and in addition to procure the material, timber, and stone necessary to rebuild and refill the superstructure of the damaged cribs. This work can not well be specified, and, as in similar cases, it is proposed to do the work by hired labor, contracting only for the delivery of the material.

Should the project and specifications be approved, it is requested that the inclosed advertisement and accompanying letter to the chief clerk of the War Department be forwarded, and that authority be given to print 250 copies of the specifications.

Very respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers, Bvt. Lieut. Col., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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K K 11.

IMPROVEMENT OF HOLLAND (BLACK LAKE) HARBOR, MICHIGAN.

The present project, originated in 1866, and amended in 1873, 1879, and 1884, has in view a 12-foot navigation between piers and revetments 200 feet apart, from Lake Michigan into Holland (or Black) Lake.

The north pier consists of 713 linear feet of crib work and 1,137 linear feet of pile revetment, extending to Black Lake, and projects 530 feet beyond the present shore line. The south pier consists of 696 linear feet of crib work and 993 linear feet of pile work, and projects 690 feet beyond the present shore line. At its Black Lake end the south revetment connects with a pile wing, extending some 320 feet to the shore of the lake.

Although the protective works of the channel have attained the full projected development, it is not possible to maintain the intended depth of navigation for any length of time, in spite of frequent dredging. The available depth on July 27, 1891, was only 12 feet, although the channel had been dredged to 14 feet during May and July, and after again deepening it with the Government dredge between August 5 and 17 to 16 feet, the depth of water had diminished to 13 feet on September 13, and to 7 feet on December 18. In May, 1892, the available depth of water was only 7 feet. The reason for this state of affairs is the insufficient projection of the piers and the permeable nature of the inshore revetments. Although there is usually a depth approaching 20 feet immediately in front of the piers, a bar with sometimes only 10 or 11 feet on the crest stretches across the entrance just beyond, and the real 15-foot curve of Lake Michigan is about 500 feet outside the end of the piers. A considerable part of the revetment is built on top of the remains of old brush dikes, constructed at private cost previous to the time at which the Government took charge of the harbor. The imperfect foundation permits large quantities of sand to wash through the work, and this together, with the material swept into the entrance around the end of the piers during storms, and at times, when, in consequence of the difference in the level of the two lakes, the current runs toward Black Lake, soon fills up the newly dredged channel.

As previously mentioned, the Government dredge returned here August 5 and by August 17 it had made a cut 25 feet wide and 16 feet deep along the middle of the channel dredged out in May and June, thus again restoring a navigation of 14 feet from lake to lake. The sand removed measured 3,120 cubic yards. At the opening of navigation in 1892 the available depth, as already stated, was only 7 feet, and the dredge returned to the harbor on June 24 with instructions to redredge the entrance.

In October and November, 1891, repairs were made to the piers and revetments, consisting of the closing of a gap in the channel wall of the south pier at the junction of the crib and pile work, refilling with new brush the south revetment for 308 linear feet (Station 6+80 to 9+88) and the north revetment for 100 feet (7+15 to 8+15), placing a small quantity of brush along the rear of the north revetment (Station 7+72 to 8+48) and cutting down to water surface the north revetment from Station 12 + 62 to 16+22, a distance of 360 feet, and rebuilding the same with three courses of new timber and refilling it with new brush.

Two hundred and eighty-eight linear feet of sand fence were built on

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the north beach and 304 feet on the south beach, with some 40 feet of vertical fence on the back wall of the north pier at shore line, to stop the flying sand from blowing into the waterway.

A permanent bench mark was established on the stone foundation of the light-keeper's dwelling and connected by duplicate levels with the United States gauge. Its elevation is 6.98 feet above the zero of the gauge. A series of accurate water-gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of procuring data for the adjustment of the zero of the gauge to a uniform level with the gauges at the other harbors.

To make the revetments subserve their purpose of excluding sand from the channel they should be sheet piled, the north pier from Station 5+10 to 12+60, or 750 feet, and the south pier from Station 5+50 to 12+90, or 740 feet. As it may be impossible to drive sheet piles along the rear of the works on account of the brush and driftwood bottom, it may be necessary to drive them along the face of the channel wall, and in that case they must be protected by special guard piles and waling timbers.

The remainder of the north revetment from Station 16+22 to 18+50, or 228 linear feet, should be rebuilt above water, and some minor repairs made to the rest of the works.

The available balance, July 1, is $2,100, and it is proposed to use this for dredging and incidental repairs.

The estimate for the fiscal year 1894 is: Sheet piling, north and south revetments, 1,492 linear feet, $7,460; general repairs of existing works, including new superstructure of 228 feet of north revetment, $5,000; dredging channel, $3,000, which, with contingencies, makes $17,000.

In addition, provision should be made for further extension of the piers, for which purpose the project should be amended to reach the 15-foot contour in the lake.

The Light-House Establishment maintains a fifth-order harbor light, and the Life-Saving Service a station on the south pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at Black Lake, Michigan.

August 30, 1852	$8,000.00	March 3, 1879	$6,000.00
June 23, 1866	55,615.31	June 14, 1880	6,000.00
March 2, 1867	51,000.00	March 3, 1881	6,000.00
July 11, 1870	10,000.00	August 2, 1882	10,000.00
March 3, 1871	10,000.00	July 5, 1884	15,000.00
June 10, 1872	10,000.00	August 5, 1886	5,000.00
March 3, 1873	12,000.00	August 11, 1888	5,000.00
June 23, 1874	15,000.00	September 19, 1890	10,000.00
March 3, 1875	15,000.00		
August 14, 1876	15,000.00	Total	274,615.31
June 18, 1878	10,000.00		

Original estimated cost of the work, 1866, amended in 1873, 1879, 1884, and 1892	$291,615.31
Whole amount appropriated, 1852, to and including act of September 19, 1890	274,615.31
Whole amount expended to June 30, 1892	272,242.87
Amount carried to surplus fund	1.19

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Money statement.

July 1, 1891, balance unexpended	$6,827.62
June 30, 1892, amount expended during fiscal year	4,456.37
July 1, 1892, balance unexpended	2,371.25
July 1, 1892, outstanding liabilities	212.55
July 1, 1892, balance available	2,158.70
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	7,158.70
Amount that can be profitably expended in fiscal year ending June 30, 1894. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	12,000.00

COMMERCIAL STATISTICS, HOLLAND (BLACK LAKE) HARBOR, MICHIGAN.

Entrances and clearances.

Year.	Number.	Tonnage.
Calendar year 1891	2,676	178,300

*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Bark ... cords	10,000	10,000	Butter ... tons		2,150
Brick ... M	1,250	2,000	Coal ... do		8,700
Butter ... tons		67	Flour ... barrels	70,000	7,000
Coal ... do		22,000	Fish ... tons		12
Grain ... bushels	170,000	5,100	Fruit ... do		8,963
Hay and feed ... tons		1,320	Farm products ... packages	16,802	580
Iron ... do		123	Furniture ... do	420,000	17,430
Laths ... M	300	90	Grain ... bushels	30,000	900
Lumber ... M feet, B. M	12,000	21,000	Hay and feed ... tons		5,620
Lime and cement ... barrels	3,060	398	Live stock ... head	1,000	180
Leather and hides ... tons		780	Leather and hides ... tons		742
Logs ... do		22,000	Lumber ... M feet, B. M	1,437	2,515
Miscellaneous freight ... do		5,611	Machinery ... tons		3,715
Machinery ... do		1,011	Potatoes ... bushels	30,000	900
Merchandise ... packages	270,000	1,918	Stone ... cords	3,926	23,137
Posts ... number	1,000	200			
Salt ... barrels	6,200	866			
Stone ... tons		100			
Slabs ... cords	2,000	5,376			
Shingles ... M	2,000	250			
Total		100,610	Total		82,544

K K 12.

IMPROVEMENT OF SAUGATUCK HARBOR, MICHIGAN.

The project for this improvement was adopted in 1869 and revised in 1875 and 1882. It was originally proposed to create a 12-foot navigation, 200 feet wide, to be prepared and maintained by dredging at the

* Compiled from statement furnished by W. C. Walsh, esq., Holland, Mich.

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mouth of the Kalamazoo River, and protected by parallel piers extending to the 12-foot curve in Lake Michigan, following the line indicated by the slab revetments built at local expense previous to the time at which the Government took charge of the harbor. At the time of making the original estimate it was recognized by the Engineer in charge that the sharp bend just above the entrance, and especially the large area of shifting sand north of the entrance, were disadvantageous features (see Annual Report for 1876, page 509):

Near the village of Singapore, where the river makes a bend * * * is a low piece of ground, showing the probable outlet of the river at some remote period. This sort of gully is about 400 to 500 feet in width, and the ground on either side of it is rolling, and 10 to 15 feet higher. The distance across this neck of land is 990 feet, and the average height above the lake surface is about 7 feet. It might be true economy for a permanent work to cut across this neck of land and make the improvement at that point, but on account of the improvements already made at the present entrance of the river, which are available, estimates for opening this channel were not made, the expenditures being deemed too great.

It may also be stated that an additional reason for adhering to the existing river channel was the fact that it had already a navigable depth of about 8 feet, which encouraged the belief that it could be deepened effectively to 12 feet.

The efforts to improve the present entrance, however, by remodeling and extending the existing revetments from the lake along the south bank of the river to above the bend and revetting the north bank at the bend and at the entrance proved unavailing. The revetment in the bend was repeatedly undermined, and the sands from the naked waste north of the harbor poured steadily into the channel under the weight of the northwest gales, and repeated dredging insured an entrance depth of but 10 feet, and for short periods only.

In 1882 it was concluded that the depth of 8 feet then existing, and from which the draft of water had varied little for many years, was probably sufficient for "the present and prospective commerce," and that the appropriations should be applied merely to maintaining the works in their then existing condition.

The last appropriation was made for this harbor in August, 1888, since which time the entrance has been kept partially open by the occasional service of a dredge.

The dredging of May, 1891, was instrumental in maintaining a tolerably navigable channel till the fall of the year, but in May, 1892, the actual depth on the bar, covering the entire width of the harbor, nearly opposite the light-keeper's dwelling, was found to be only 3 feet; at the end of the piers the water was 6 feet deep, and on the outlying bar 8 feet.

The steamers trading to Saugatuck and requiring from 7 to 8 feet of water have been in the habit of scouring out a temporary channel with their propeller wheels, but it is evident that a channel obtained by such means is but temporary, as the sands are only removed from one place in order to find lodgment in other parts of the channel.

In addition, the Kalamazoo River has been in a state of flood during the greater part of May and June of this year, and the rapid current brought down large quantities of sand from the unprotected banks above the bend to fill up any channel that could have been made. The Government dredge is expected to arrive here in the first week of July to reopen the entrance, which will exhaust the present available balance of $1,300.

If it is proposed to continue expenditures at this point, new estimates

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should be made for the extension and completion of the necessary works. The present conditions are as follows:

The piers and revetments are in urgent need of repairs. The south pier from the outer end to Station 25+24, 2,524 linear feet, is a total wreck. It should be rebuilt above the water surface and refilled with brush and stone. New filling is also needed in the remaining 1,330 feet of the south revetment and in the north pier 714 feet, and the upper end of the south revetment should be connected with the shore to keep the river from cutting behind it. A great part of the north revetment in the bend is swallowed up by the sand advancing from the north, and the remaining part has become a danger to navigation, as it has canted over into the channel, a considerable portion of the piling being below the water surface. It should be replaced by a more substantial structure.

The recent soundings show the 5-foot curve of Lake Michigan to be 400 feet in advance of the north pier and about 100 feet from the south pier. With this condition of affairs it can not be expected to maintain a navigation of even 8 feet.

A permanent bench mark was established on top of stone foundation southeast corner of light-keeper's dwelling (the former light-house), and connected by duplicate levels with the United States gauge. It is 19.73 feet above zero of gauge.

A series of accurate water-gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform elevation with the gauges at the other harbors.

To preserve the present structures, pending serious attention to the completion of the improvement, the outer 2,524 feet of the south pier should be rebuilt above the water surface and the remainder of the south revetment and the outer north pier, altogether 2,050 feet, should be refilled with brush and stone. This is estimated to cost $25,000. For dredging the sum of $5,000 is estimated required. The total estimate for 1894 is, therefore, $30,000.

The light-house establishment maintains a fifth-order light on the south pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at Saugatuck, Mich.

July 25, 1868	$23,900	March 3, 1879	$5,000
April 10, 1869	6,039	June 14, 1880	5,000
July 11, 1870	10,000	March 3, 1881	5,000
March 3, 1871	10,000	August 2, 1882	8,000
June 10, 1872	15,000	July 5, 1884	4,000
March 3, 1873	10,000	August 5, 1886	8,000
June 23, 1874	10,000	August 11, 1888	5,000
March 3, 1875	10,000		
August 14, 1876	3,000	Total	140,439
June 28, 1878	2,500		

Original estimated cost of the work, 1867, modified in 1869, 1870, 1875, and 1882	$175,699.46
Whole amount appropriated from 1868 to and including act of August 1888	140,439.00
Whole amount expended to June 30, 1892	139,094.25

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Money statement.

July 1, 1891, balance unexpended	$1,458.30
June 30, 1892, amount expended during fiscal year	113.55
July 1, 1892, balance unexpended	1,344.75
July 1, 1892, outstanding liabilities	10.00
July 1, 1892, balance available	1,334.75
Amount appropriated by act approved July 13, 1892	5,000.00
Amount available for fiscal year ending June 30, 1893	6,334.75
Amount (etimated) required for completion of existing project	30,260.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	30,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, SAUGATUCK HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	300	$422.84	.....
1885	265	118.86	.....
1886	(*)	(*)	.....
1887	(*)	(*)	.....
Calendar year:			
1888	662	.....	132,400
1889	314	.....	76,300
1890	178	.....	42,000
1891	492	.....	120,000

* Not stated.

*Receipts and shipments by vessel, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Brick ... M	15	38	Flour ... barrels	349	35
Coal ... tons	.....	125	Fish ... tons	.....	60
Lime and cement ... barrels	300	39	Flags ... do	.....	4
Lumber ... M feet, B. M	100	175	Fruit and vegetables ... do	.....	17,513
Merchandise ... tons	.....	520	Farm produce ... do	.....	20
Machinery ... do	.....	70	Household goods	.....	9
Salt ... barrels	100	14	Live stock ... heads	16	8
Shingles ... M	50	6	Machinery ... tons	.....	35
Piles ... M	40	640	Merchandise ... do	.....	11
			Meats ... do	.....	93
Total	.....	1,627	Total	.....	17,788

* Compiled from statement furnished by Messrs. Griffin & Henry.

K K 13.

IMPROVEMENT OF SOUTH HAVEN HARBOR, MICHIGAN.

The official project, adopted in 1866 and modified in 1869, 1872, and 1888, provides for a channel 12 feet deep, 180 feet wide, and protected by piers and revetments at the entrance, and extending up Black River to the highway bridge.

The existing works are as follows:

On the north side: 255 feet crib work 32 feet wide, built in 1872 to 1874; 30 feet crib work 30 feet wide, built in 1871; 321 feet crib work 20

feet wide, built in 1868 and 1869; 524 feet pile work built in 1876, and 462 feet plank beam revetment built 1879. The total length is 1,592 feet, and the pier projects 700 feet beyond the present shore line.

On the south side: 50 feet cribwork 30 feet wide, built 1888; 153 feet crib work 32 feet wide, built 1871–1874; 352 feet crib work 20 feet wide, built 1868; 143 feet pile work, built 1878, and 855 feet plank beam revetment, built 1878 to 1882. The total length is 1,553 feet, and the pier projects 520 feet beyond the present shore line.

The dredging, which was in progress at the beginning of the fiscal year, was completed August 4, 1891, giving a channel 13 feet deep and 50 feet wide. Eleven thousand six hundred and seventy cubic yards were removed after July 1. At the opening of navigation this year the entrance was found to have again shoaled to 10 feet, and the Government dredge reopened the channel to a depth of 14 feet and width of 50 feet between May 21 and June 23. A few shoals in the river above the revetments were also removed, and the quantity dredged measured 13,830 cubic yards.

The repairs of the outer crib, north pier, were completed. Close piles were driven around the outer half of the crib and connected by means of caps and screw bolts to the old timber work, and the new superstructure built up on the work thus strengthened. The gaps in the side walls were closed with vertical timbers and screw bolts, and the repaired work was filled with stone. One hundred linear feet of the outer end of the south side pile work, at shore-line, where it joins with the crib work, was provided with a double row of sheet piling. This place has always permitted large quantities of sand to pass through into the channel. Although it was not possible to drive the sheet piles very deep, owing to the mass of brush and driftwood in the bottom, it is believed that this part of the work is now practically sand tight.

The north pile revetment, 524 feet long, was also double sheet piled along the rear wall and refilled with new brush, ballasted with the old stone. The same difficulty was encountered here in driving sheet piles as on the south side, but the indications are that the seepage of sand through the revetment has been stopped.

The conversion of the north plank beam into a sheet pile revetment has been commenced. The work was cut down to 3 feet above the water surface, and is to be provided with a new cap over the front piles and a wale streak along the water line, additional piles along the front wall, a double row of sheet piles to penetrate to not less than 14 feet below the water, and anchor piles 10 feet in the rear connected with the front walls by iron tie rods. This part of the revetment is 460 feet long, and it is expected to complete the conversion during the month of July. One hundred and ninety-two linear feet of sand fence was built on the north beach, and the vertical fence on the rear wall of north pier was moved out to the shore line, where it will do better service. The end wall of south pier was repaired.

During the early spring the Government pile-drivers and the construction scow received needed repairs to fit them for the season's work.

A permanent bench mark was established on top of brick foundation at southwest corner of Mr. Hallock's house on the northeast corner of Michigan avenue and St. Joseph street, and connected by duplicate levels with the United States gauge. It is 41.68 feet above zero. A series of accurate water gauge readings was commenced June 1 to be continued through June, July, and August, for the purpose of obtaining data for adjusting the zero of the gauge to a uniform level with the gauges at the other harbors.

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After the completion of the repairs now in progress the works will be in the following condition: The north pier, although most of it is very old, will not need any repairs, except some occasional patchwork, for one or two years to come.

The outer 200 feet of south pier is in a fair state of preservation, and will need no repairs in the immediate future, but the 20-foot crib work from station 9 + 98 to 13 + 50, 352 linear feet, which is now 24 years old, is in urgent need of rebuilding above the water surface, as the timber work is all rotten and barely hangs together. As the best water in this harbor is habitually close to the south pier, this part is particularly exposed to injury from passing vessels, and its repairs should not be delayed any longer.

No repairs are proposed at this time for the south plank beam revetment, but the time is not far distant when it will be necessary to strengthen it with anchor piles in the rear, and tie rods, and when that time comes it may be found desirable to provide it with sheet piling.

The repairs now being made to the north revetment will help materially in preserving the needed depth of water in the harbor, but the two principal causes of the interfering shoals will still exist unimpaired. These are the insufficient development of the piers, and the unprotected condition of the north bank of Black River above the revetments.

The present piers do not project beyond the general 10-foot curve in the lake, and although there is usually a depth of 14 to 16 feet at the end of the piers, a bar with sometimes not more than 10 feet on its crest stretches across the entrance immediately beyond, and even after the piers shall have attained their full length as intended by the present project, which provides for an addition of 150 feet to the north pier and 200 feet to the south pier, they will fall some 300 feet short of reaching the proper depth in the lake.

The north bank of Black River is in its natural state, although the best water is very close to it, and it is subject to erosion from the current of the river, when in flood, and from the waves and suction of passing vessels. It would seem to be the duty of the riparian owners to properly revet the bank, in order to assist in maintaining the desired depth of navigation.

With the working balance of $900 it is proposed to complete the repairs of the north revetment, now under way.

For the fiscal year 1894, the estimate is as follows: For repairs to south pier and general repairs, $5,000; for completing the existing project, 7 additional cribs, $42,000; for dredging, $3,000, which, with 10 per cent for contingencies, makes $55,000.

The light-house establishment maintains a fifth-order light on the south pier, and the Life-Saving Service a station on the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for improving harbor at South Haven, Mich.

March 2, 1867	$43,000	June 14, 1880	$5,000
July 11, 1870	10,000	March 31, 1881	5,000
March 3, 1871	15,000	August 2, 1882	10,000
June 10, 1872	12,000	July 5, 1884	7,500
March 3, 1873	20,000	August 5, 1886	5,000
June 23, 1874	10,000	August 11, 1888	10,000
March 3, 1875	10,000	September 19, 1890	15,000
August 14, 1876	10,000		
June 18, 1878	12,000	Total	207,000
March 3, 1879	7,500		

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Original estimated cost of the work, 1866, amended in 1869, 1872, and 1892	$262,000.00
Whole amount appropriated from 1866 to and including act of September 19, 1890	207,000.00
Whole amount expended to June 30, 1892	203,872.45

Money statement.

July 1, 1891, balance unexpended	$11,898.94
June 30, 1892, amount expended during fiscal year	8,771.39
July 1, 1892, balance unexpended	3,127.55
July 1, 1892, outstanding liabilities	2,217.77
July 1, 1892, balance available	909.78
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	10,909.78
Amount (estimated) required for completion of existing project	40,426.80
Amount that can be profitably expended in fiscal year ending June 30, 1894	45,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS, SOUTH HAVEN HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	466	$555.72	.....
1885	361	204.50	.....
1886	283	118.55	.....
1887	264	.....	52,800
1888	420	.....	29,134
Calendar year:			
1889 (estimated)	1,080	.....	.....
1890	2,246	.....	128,880
1891	2,994	.....	201,380

Receipts and shipments by vessel, 1891. *

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Bark ..... cords	753	875	Apples and pears ..... barrels	34,993	3,499
Brick ..... M	65	162	Bark ..... cords	250	250
Coal ..... tons	.....	500	Brick ..... M	130	325
Lath ..... M	360	108	Fish ..... tons	.....	38
Leather ..... tons	.....	97	Flour ..... barrels	1,250	125
Lumber ..... M. feet, B. M	6,120	10,710	Grapes and small fruit, ... packages	76,243	1,144
Lime and cement ..... barrels	720	94	Gravel ..... cubic yards	30	39
Machinery ..... tons	.....	15	Hides ..... tons	.....	136
Merchandise ..... do	.....	380	Lumber ..... M. feet, B. M	1,045	1,828
Posts ..... number	5,000	100	Live stock	.....	163
Salt ..... barrels	1,360	140	Merchandise ..... packages	.....	380
Shingles ..... M	2,132	267	Peaches ..... do	1,073,332	6,500
Stone ..... cords	75	469	Slabs ..... cords	350	875
Total	.....	13,417	Total	.....	15,302

* Compiled from statement furnished by C. J. Monroe.

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K K 14.

IMPROVEMENT OF ST. JOSEPH HARBOR, MICHIGAN.

The official project, adopted in 1866 and modified in 1874 and 1875, is to secure a channel of entrance from Lake Michigan into St. Joseph Harbor, 270 feet wide and 16 feet deep, protected by piers and revetments. Thence to Benton Harbor it is designed, as later authorized in 1880, to carry 13 feet through the Benton Harbor Canal, widening the channel to 100 feet.

The channel entrance from Lake Michigan into St. Joseph Harbor is protected on the north side by a pier consisting of 457 linear feet of crib work, 30 to 24 feet wide, and built between the years 1875 and 1881, of 373 linear feet of old crib work built previous to 1886, and of 666 linear feet of pile revetment built in 1886–'87, and on the south side by 606 linear feet of pile pier built 1867 to 1872, and of 213 linear feet of old crib work built previous to 1866. The inner end of the north revetment is connected with the shore and the new light-house depot bulkhead by a pile wing 179 feet long. The north pier projects 600 feet beyond the present shore line and the south pier 540 feet.

The 373 feet of old crib work in the north pier has been maintained by means of repeated patching, sustaining piles, tie rods, etc., for the last few years, but the time has come when this is no longer practicable, and the work should be rebuilt above the water line, and as a considerable portion of the channel wall below the water has been lost, close piling will have to be driven here to support the new superstructure. To rebuild this work in proper shape is estimated to cost $5,000.

The filling in the north revetment has settled considerably, and in order to avoid the loss of the stone ballast and exclude the sand of the bank behind from the channel it should again be refilled with brush. This it is estimated will cost $600. Some minor repairs to the other parts of the north pier and to the south pier, which will not cost above $1,000, will put the existing channel revetments at the entrance into good repair for some years to come.

The present constructions are not sufficient, however, to maintain the projected entrance depth, owing to their insufficient extension. In the Annual Report for 1891 it is said:

> The accumulation of sand from the action of the winds and the currents is against the north pier, and this has now occasioned bars and shoals of 10 feet beyond the end of the north pier and overlapping to the southward across the entrance. In fact the buoy marking the entrance, as established this spring about 1,000 feet a little north of west from the end of the north pier, marks the south end of a shoal upon which there is but 13 feet of water.

The conditions at the entrance went from bad to worse until, in the the fall of 1891, a shoal with only 7 feet of water on it overlapped the end of north pier and projected nearly 100 feet in front of it into the channel. Several vessels ran aground on it while trying to enter the harbor, but all escaped without serious damage, as the lake happened to be quiet at the time.

Subsequently this shoal was partially scoured out under the combined influence of southwesterly gales and the river current, but the materials were distributed farther out and added to the ridges extending from the north across the harbor entrance, raising the summit of the first bar about 500 feet beyond the end of north pier to 11 feet below the water surface.

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Under date of November 10, 1891, a special report was made (copy herewith), the conditions being such as to greatly alarm the vessel interests and threaten the practical closing of the harbor. In fact, for a time, one of the transportation companies that had made provision for continuous shipments was compelled to forward its freights to Grand Haven and tranship from there.

In December the best crossing of the outer bar was 1,200 feet distant from the end of the north pier, and about 500 feet south of its prolonged channel face, with 15 feet of water, which the wave action practically reduced to little better than 12 or 13.

At the earnest solicitaton of the Milwaukee and Eastern Transit Company, the Government dredge *Farquhar* endeavored to open an 18-foot channel, 50 feet wide, across the 11-foot shoal during the latter half of December, the company agreeing to pay the expenses of the plant while idle on account of the weather. As a matter of fact but five days were found fit for work between December 11 and January 5, and it having become obvious to the company that further dredging on the bar was futile, the attempt in that direction was discontinued and the plant laid up.

The weather conditions of the past winter were more nearly normal than had been the case for several years. Ice formed in considerable quantities in the lake and its beneficial action in protecting the water from the weight and action of storms was made particularly evident at St. Joseph. With the surface covered, wave action was suspended and the current of the river had its normal effect in scouring out a channel to a navigable depth nearly in the direct prolongation of the piers. Thereafter less difficulty was experienced and the winter business of the port continued with fair measure of regularity.

The freshets this spring have been of unusual volume and persistence, and immense amounts of silt have been brought down by the river current. Large deposits were made on the bars outside the entrance, but the material was soft and a vessel could plow through 2 or more feet of it without serious hindrance. In time it is probable that this lighter material will disappear from the channel crossings of the bars and be elsewhere distributed.

The present project does not provide for any further pier extensions, but, as stated, in the special report of November 10, 1891, it is evident that the piers should be built out to beyond the outer bar if the required depth at the entrance is to be secured.

The Government constructions at and below the mouth of Benton Harbor Canal consist of some 1,390 linear feet of plank beam revetment on the north side of the canal, with a gap of 190 feet nearer the middle for the passage of the waters of the Paw Paw River, of 728 feet of pile work 14 feet wide, called the wing dam, connecting at the upper end with the revetment, and continued at the lower end by 194 feet of close piling. The wing dam and piling constitute a sort of training dike to guide the combined waters of the St. Joseph and Paw Paw rivers in a collected stream toward the lower harbor and direct them toward the draw opening in the Chicago and Western Michigan Railroad bridge. In 1891, the Cincinnati, Wabash and Michigan Railroad extended their track from Benton Harbor down the north canal bank to the wing dam and built a grain elevator immediately back of it, near its upper end, and a warehouse just behind the revetment, with a view to loading and unloading vessels across these structures. The entire wing dam is at the present time decayed and the filling in it has settled

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to such an extent that throughout the greater part of its length the water is 5 to 6 feet deep in it. In this condition it naturally is incapable of subserving the purpose for which its was built, and should in part be rebuilt above water and refilled. The plank beam revetment is also in a broken-down condition. There is an agreement with the railroad company whereby the company is to remove this revetment and replace it by a substantial sheet-pile structure about 10 feet farther back, thus insuring to the canal the projected width of 100 feet. The railway company, if permitted to use the wing dam, should also rebuild it as far as their works extend. It is estimated that it will cost $6,000 to repair and refill the other part of the wing dam.

The remaining part of the north bank of the canal and the winding basin at Benton Harbor are revetted by the owners, but most of these revetments are badly built and permit the soil from behind to wash into the canal. The south bank has nothing that can be called a revetment, but the city of Benton Harbor has recently passed ordinances requiring all riparian owners to properly bulkhead their fronts.

The dredging in progress at the commencement of the fiscal year was continued until October 28, 1891, and during this time the winding basin at Benton Harbor and the canal were dredged throughout to a depth of 13 feet; the main channel in the harbor below the canal was deepened to 15 feet, as well as the shoal area between the railroad bridge and the north revetment, and a channel 50 feet wide and 17 to 18 feet deep was made across the bar between the ends of the piers. The approach to the life-saving station back of north pier was also deepened, and the shoal at the mouth of the Paw Paw in the canal having reappeared, this was again dredged out before the plant left for Michigan City.

The dredge *Farquhar* again arrived at the harbor on December 11, 1891, and, as already stated, was temporarily kept in commission in the attempt to open a passage across the bar in front of the entrance.

During the winter the Government plant was repaired, and on the 16th of April the dredge resumed operations and again restored the navigation in the canal to a depth of 13 feet. The flood in the St. Joseph River, which set in early in May, made further dredging in the harbor impossible for the time being, and the plant was sent to South Haven. The total dredging during the year amounted to 57,520 cubic yards.

At the present time much complaint is made regarding the navigation in St. Joseph Harbor, the high river having brought down large quantities of sand from above, and the available depth above the railroad bridge is only 11 to 12 feet. The service of a dredge will be required here as soon as further appropriations shall have been made.

The repairs of the north revetment, by refilling with brush and stone, were completed in July, 1891, and the effect became apparent at once, as no more sand found its way through this work afterwards. A plank walk was laid over the revetment from the inner end of the elevated walk, which was rebuilt.

The incomplete portion of the superstructure of the south pier was finished. The gap in the end wall of the north pier, under the superstructure, was closed with vertical timbers, placed with the help of a diver, and end the crib filled with stone and decked. The end of the pier was subsequently injured by one of the steamers which ran aground on one of the shoals near it and broke off the end horns. The damage was repaired with extra timbers and tie rods, and a washout at station 7 in the north pier was closed with plank aprons and stone ballast.

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The Chicago and West Michigan Railway has commenced dredging out the passages through the drawbridge, in accordance with the order of the Secretary of War. They have been much delayed by the rapid current in the river, due to the persistent freshets, making dredging difficult and at times impracticable, but they are doing what they can to get the dredging done, and will have it completed in July.

In October, 1891, pursuant to renewed complaints against the Chicago and West Michigan Railway bridge as an obstruction to the harbor, a public hearing was held and subsequent report submitted under date of November 27, 1891.

A permanent bench mark was established on top of a bonding iron in the coping on the southwest corner of south abutment of the railroad bridge and connected by duplicate levels with the United States gauge. Its elevation is 6.63 feet above zero. A series of accurate water gauge readings was commenced June 1, to be continued through June, July, and August, for the purpose of obtaining data for the adjustment of the zero of the gauge to a uniform level with the gauges at the other harbors.

For the fiscal year 1894 the following estimate is submitted: For rebuilding 373 feet of old crib work in north pier, $5,000; for refilling north revetment, $600; minor repairs, $1,000; for repairing wing wall, $6,000; for additional dredging, $10,000; which, with contingencies, makes $25,000.

To this should be added the funds required for extending the piers, viz, 120 linear feet of extension of north pier, which would represent two seasons' work, and if put under one contract could be done for $100 a foot; total $120,000. The estimate for the fiscal year 1894 is therefore $145,000.

The Light-House Establishment maintains a fifth-order light at the end of the north pier, and has recently established the fourth-order revolving coast light on the bluff in St. Joseph. The Life-Saving Service has a station at the inner end on the north pier.

This harbor is included in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich.

Appropriations for St. Joseph Harbor and River, Michigan.

Act of—		
July 4, 1836		$20,000
March 3, 1837		15,000
July 7, 1838		51,113
March 3, 1843		25,000
June 11, 1844		20,000
August 30, 1852		10,000
June 28, 1864		15,000
June 23, 1866		6,000
March 2, 1867		23,000
1867—		
Allotted from harbors on Northwestern Lakes	$7,500	
Transferred in 1870 to Grand Haven Harbor	500	
		7,000
July 11, 1870		$15,000
March 3, 1871		10,000
June 10, 1872		3,000
June 23, 1874		2,000
March 3, 1875		35,000
August 14, 1876		12,000
June 18, 1878		12,000
March 3, 1879		6,000
June 14, 1880		8,000
March 3, 1881		10,000
August 2, 1882		12,000
July 5, 1884		15,000
August 6, 1886		10,000
August 11, 1888		12,000
September 19, 1890		20,000
Total		374,113

Original estimated cost of the work as revised in 1892	$519,113.00
Whole amount appropriated from 1836 to and including act of September 19, 1890	374,113.00
Whole amount expended to June 30, 1892	272,831.29
Amount carried to surplus fund	.80

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Money statement.

July 1, 1891, balance unexpended	$11,102.64
June 30, 1892, amount expended during fiscal year	9,821.73
July 1, 1892, balance unexpended	1,280.91
July 1, 1892, outstanding liabilities	632.33
July 1, 1892, balance available	648.58
Amount appropriated by act approved July 13, 1892*	60,000.00
Amount available for fiscal year ending June 30, 1893	60,648.58
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	85,000.00

COMMERCIAL STATISTICS, ST. JOSEPH HARBOR, MICHIGAN.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1884	560	$1,096.14	.....
1885	467	361.57	.....
1886	789	248.53	.....
1887	580	.....	144,000
1888	679	.....	208,797
Calendar year 1889	966	.....	359,925

Years.	Vessels entered.	Tonnage.	Vessels cleared.	Tonnage.
1890 (including Benton Harbor)	948	131,607	946	131,395
1891 (including Benton Harbor)	742	215,334	743	215,591

Receipts and shipments by vessel at St. Joseph and Benton Harbor, Michigan, 1891. *a*

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Cement ..... tons	.....	508	Cement ..... tons	.....	1,277
Cooperage ..... do	.....	41	Carriages ..... do	.....	1,113
Furniture ..... packages	282	12	Canned goods ..... cases	3,515	1,141
Fruits and vegetables ..... tons	.....	75	Fruits and vegetables ..... tons	.....	8,642
Feed ..... bushels	15,700	393	Fish ..... do	.....	46
Flour ..... barrels	18,525	1,853	Flour ..... barrels	10,760	1,076
Fertilizer ..... tons	.....	4	Hides ..... bundles	561	27
Groceries ..... packages	390	59	Iron ..... tons	.....	20
Iron ..... tons	.....	470	Live stock ..... head	40	8
Live stock ..... head	236	42	Lumber ..... M feet, B. M.	359	634
Lumber ..... M feet, B. M.	2,867	6,417	Merchandise ..... tons	.....	36,540
Merchandise ..... tons	.....	12,494	Nails ..... kegs	3,510	176
Paper ..... bundles	3,964	199	Paper ..... bundles	52,478	2,654
Pitch ..... barrels	100	15	Produce ..... crates	141	22
Posts	3,000	60	Pipe, sewer ..... tons	.....	120
Stone ..... cords	75	469	Rags ..... bales	517	116
Sugar ..... barrels	1,155	298	Starch ..... boxes	719	18
Sundries ..... packages	2,960	148	Sugar ..... barrels	170	43
			Sundries ..... tons	.....	1,139
			Tobacco ..... hogsheads	127	30
			Vinegar, cider ..... barrels	2,820	282
			Wool ..... sacks	165	17
Total	.....	23,552	Total	.....	55,141

a Compiled from statement furnished by the collector of customs.

* Of which $1,000 may be expended on St. Joseph River.

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*Receipts and shipments by vessel at St. Joseph and Benton Harbor, Michigan, 1891.**

Articles received.	Quantity.	Tons.	Articles shipped.	Quantity.	Tons.
Coal ..... tons..	.....	26,000	Farm produce ..... packages..	2,000	100
Lime and cement..... barrels..	2,000	325	Fruits and vegetables... tons..	.....	16,310
Lumber..... M feet, B. M..	38,250	58,012	Fish ..... do....	.....	600
Merchandise, miscellaneous, ... tons..	.....	25,000	Flour..... barrels..	15,000	1,500
Salt..... barrels...	500	175	Live stock..... head..	3,150	557
			Merchandise..... tons..	.....	12,160
Total.....	.....	103,512	Total.....	.....	31,307

*Compiled from statement furnished by the Graham and Morton Transportation Company.

John Higman, jr., president Board of Trade of St. Joseph, places the tonnage of St. Joseph Harbor for 1891 at a total of 130,189 tons.

REPORT OF MAJOR WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., November 10, 1891.

GENERAL: In compliance with Department indorsement of November 6, on the letter of November 3, from the Hon. J. C. Burrows, with inclosures to the Secretary of War, relative to the obstructions at the mouth of the St. Joseph, Mich., Harbor, I beg to report as follows:

Since the opening of navigation the conditions existing at the St. Joseph entrance have been the cause of much solicitude, and the situation has been closely observed by means of repeated partial surveys and examinations and several personal insepections.

The causes are to be found partly in general conditions disadvantageously affecting all lake navigation, and partly in local circumstances.

The matter is briefly referred to and the remedy indicated in the recent Annual Report.

The accumulation of sand from the action of the winds and currents in the lake is against the north pier, and this has now occasioned bars and shoals of 10 feet beyond the end of the north pier and overlapping to the southward across the entrance. In fact, the buoy marking the entrance, as established this spring, about 1,000 feet a little north of west from the end of the north pier, marks the south end of a shoal, upon which there is but 13 feet of water. If the official project is to be adhered to it will be needful to give some such extension as this to the north pier, leaving the question of making addition to the south pier for future consideration, although it would probably be found advisable to extend the south pier 500 feet, to a point about opposite the present end of the north pier, and about 400 feet south of it.

St. Joseph Harbor is one of the oldest on the lake, having been selected as early as 1836 for improvement as a harbor of refuge. The works were gradually extended and later included the maintenance of the canal leading to Benton Harbor.

Of recent years the appropriations made were expended mainly in dredging and repair work as the age of the pier construction required, and the increasing requirements of navigation called for deeper channels. The circumstances exterior to the piers continued tolerably satisfactory, with entrance depth of 13 to 15 feet.

It is now some twelve years since any considerable extension has been made to the north pier, which by reason of the accumulation of sand against it is the important one at St. Joseph, and during this period the accretions on the north foreshore have continued, until they have at length reached a point where they have overlapped the pier and are pushing around to the southward in great volume across the harbor entrance.

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This movement and the resulting formation of extensive shoals have been greatly expedited by the open winters of the past three years, giving the northwest gales free sweep on the lake, and at this time are especially aggravated by the abnormal level of the lake, which is about 1 foot lower even than the extraordinary low water of one year ago.

The results are shown in the accompanying tracing from the most recent survey.

During the earlier part of the season the course entering was nearly straight in after getting the outer black spar buoy abreast.

Later, a small shoal formed close to the end of the north pier, which has since developed into the extensive areas inclosed within the 10-foot contour, with depths of 7½ and 8 feet upon them. At present this shoal lies across the prolongation of both piers and has crowded the entrance to the southward, toward the 10½ and 11 foot shoal lying on that side, the heavy gales in October having occasioned the rapid and large accumulations.

The obvious remedy is the westward extension of the north pier past the black buoy to about the 15-foot contour, a distance of some 1,200 feet, which would cost $100 per linear foot.

I believe this extension to be indispensable to the maintenance of the harbor, and that it should be provided for as early as practicable. As to temporary measures for the relief of navigation, I regret to say that I know of none that I could recommend or suggest at this time. During the fall and winter months the lake is kept in a state of almost incessant agitation, such as to make it impracticable to operate dipper dredges on the bar, and such scanty work as might be done by awaiting a brief opportunity would be undone in an hour or two. The appropriation balance to the credit of the St. Joseph Harbor is but $1,500, and in any case it is manifestly hopeless for a dredge to contend with or make any useful impression on such an accumulation as has been heaped up southward of the line of the north pier. I believe that the present conditions will probably become no worse, as the outflow of the river has a certain effect in conserving the channel, and in all probability the lake will rise from heavy rains and continue to do so, so as to raise the level 1½ feet above the present stage.

Meanwhile the channel has a navigable depth of 13 or 14 feet, which may improve, and with judgment in selecting the best water, it may continue to be used in ordinary conditions.

Respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers,
Bvt. Lieut. Col., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

K K 15.

IMPROVEMENT OF ST. JOSEPH RIVER, MICHIGAN.

The project of March, 1889, contemplates securing a depth of 3 to 4 feet from St. Joseph to Berrien Springs, a distance of 25 miles, by the removal of snags and bowlders and the construction of wing dams where needed.

Operations were resumed July 13, and continued till the end of September, when the available funds were exhausted. At Twin Springs

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Island the whole current was diverted into the right-hand channel by the construction of a closing dam between the island and the left bank, a crude form of training dike at the foot of the island was repaired, and subsequently an additional wing dam, 100 feet long, was built about 1 mile below to maintain a navigable channel across the shoal caused by the scour of the concentrated current above. A second dam was built at the head of Long Reach, 7 miles from St. Joseph. The river is very wide in this locality, and it is probable that additional dams will be needed to insure a navigable depth.

Farther down the river at Royalton Island, some 3 miles above St. Joseph, the navigation is affected by the stage of Lake Michigan, which during the last few years has been very low, and in the fall of the year, when the river carries a reduced volume of water, the available depth in this locality is usually small. In order to improve matters here as much as the limited means would permit, a number of water-soaked logs were arranged as a kind of dam across the right-hand channel, and the left-hand channel was further confined at the foot of the island by a dam of the same material.

Before closing operations the entire stretch of river from Berrien Springs down was cleared of such snags as still remained to obstruct the best water. Altogether 318 snags, 15 overhanging trees and 7 large bowlders were removed, and at the end of September an uninterrupted navigation of at least 3 feet was insured for the rest of the season.

It is probable that these rude measures of relief will not suffice to keep the river in good condition for any great length of time. The low-water channel will need to be restricted in a greater degree and at a greater number of points, and snags will be brought down and lodged in the channel at every high water. It is also probable that the banks will need protection at several places to prevent erosion. Heretofore the constructions have been inexpensive, as the materials, such as brush and stone, cost only the labor of gathering them, and the necessary towing of the plant was done gratuitously by Mr. Graham, the owner of the river steamer. It is probable that in future the cost of similar work will be increased, as the supply of suitable stone is now nearly exhausted, and the required brush may soon have to be paid for.

For further operations it is recommended that an appropriation of $2,000 be made.

Appropriations for improving St. Joseph River, Michigan.

August 11, 1888	$2,500.00
September 19, 1890	1,000.00
Whole amount appropriated, including act of September 19, 1890	3,500.00
Whole amount expended to June 30, 1892	3,450.27

Money statement.

July 1, 1891, balance unexpended	$1,003.18
June 30, 1892, amount expended during fiscal year	953.45
July 1, 1892, balance unexpended*	49.73
Amount that can be profitably expended in fiscal year ending June 30, 1894. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	2,000.00

* The river and harbor act approved July 13, 1892, provides that $1,000 of the appropriation for improving St. Joseph Harbor may be expended on St. Joseph River.

COMMERCIAL STATISTICS, ST. JOSEPH RIVER, 1891.

One steamer, *May Graham*, 95 tons, load draft 30 inches, plying between St. Joseph and Berrien Springs.

E. A. Graham & Co., of St. Joseph, Mich., states that the freight carried on the *Graham* amounted to about 2,600 tons.

K K 16.

IMPROVEMENT OF MICHIGAN CITY HARBOR, INDIANA.

The works of this harbor consist of the improvement of Trail Creek by entrance piers 100 feet apart and dredging the creek bed to 13 feet (the local authorities and owners attending to the bank revetting), constituting the "Inner Harbor," and of extensive breakwater and pier constructions in the open lake, constituting the "Outer Harbor."

OUTER HARBOR.

This harbor [extract from Annual Report for 1890] consists of several works constructed at different dates and designed for the protection of the general lake commerce in view of the great development of the shipping industries and the exposed location of the harbor at the head of the lake.

The "Outer Basin," projected in 1870 and completed in 1884, is inclosed on the east by the "east pier" (originally 1,100 feet in length, now reduced by the advance of the shore line to half that), on the north by the "breakwater," 1,400 feet in length, and on the west by the outer 550 feet of the "west pier," prolonged for that purpose. The entrance, 215 feet wide, common to the basin and the creek, is at the northwest angle, fronting about north-northwest down the lake.

It was a part of the project that the inclosed area of this "Outer Harbor" should be dredged to a depth of 14 feet, furnishing some 40 acres of protected anchorage, but this has never been done, and if it were the basin would still be of no commercial value whatever for the reason that the entrance, 215 feet, is too narrow for a harbor of refuge and being directly open to the heaviest storms on the lake, viz., those from the northwest quadrant, admits the sea freely into the basin.

Prior to the completion of these structures it was found that the heavy sea, in conjunction with the powerful currents sweeping westwardly across the mouth, made the entrance extremely hazardous, for which reason a spur pier, locally termed the "Breakwater Pier," projecting at right angles from the west end of the breakwater 500 feet northward into the lake, was designed in 1880 and completed in 1889. This pier has been found of advantage, but the inherent difficulties of the situation remain. There was, therefore, no "harbor of refuge" for vessels needing shelter from the storms of the lake between Chicago and Grand Haven, nor, in fact, could the "Outer Harbor" at Michigan City furnish it so long as the northward opening in the lake was retained, so that, in 1882, the project for the "outer breakwater" was adopted, in conformity with which work was begun last season by the construction of the first ten cribs. The project provides that the eastern end of the new breakwater shall begin 400 feet west of the north end of the Breakwater Pier, leaving that space open for an entrance; thence extending westerly 1,000 feet to the angle in the work; thence inclining towards the shore at an angle of 135 degrees, and extending another 1,000 feet.

The report points out the disadvantage of the proposed direction of the outer arm of the new breakwater, approaching as it does with its outer end to within 600 feet from the then 18-foot curve, thus making any future extension of the breakwater impracticable, and recommends a modification of the project so as to change the proposed alignment to one nearly parallel with the shore line.

Also, as a necessary condition of the utilization of the large expendi-

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tures made in constructing the outer basin, that the 400-foot opening be closed in order to shelter the inclosed area of the "outer basin" and thus make it available for the intended purpose. These recommendations have no less validity at this time.

The end of the old breakwater, where it joins with the breakwater pier, was run into by the steam barge *Prentice* in November, 1891, and, being very old and tender, it was badly damaged, the eleven top courses of timber being broken. Repairs of this part of the work were commenced in May, 1892, using timber and iron on hand at the harbor.

The structures forming the entrance to the "inner harbor" consist of the so-called "west pier" and the "old east pier." The former has been repaired during recent years and only needs a little additional filling to place it in good order, but the outer 700 feet of the old east pier, which is now twenty-four years old, is quite gone, the extreme end having disappeared to several feet below the water surface, and the rest will soon follow, unless speedily rebuilt. A portion of this pier would be removed upon the completion of the project, but as its service is required as a revetment for the maintenance of the entrance to the "inner harbor," and as the 10-foot curve in the "outer basin" is now even with the outer end, it should be rebuilt unless the "gap" is closed. It is estimated that this will cost $8,000.

The operations during the year have consisted in completing the superstructure over the 500 feet of crib work in the outer breakwater. These cribs were placed on a heavy stone foundation in 1889, rising 2½ feet above water surface. When work was commenced on the superstructure, in the spring of 1891, they had partly settled on the lake side to 4 feet below water, indicating a total subsidence into the lake bottom of 6 to 7 feet. The submerged portion was leveled up and a six course superstructure built on top, the upper course having an elevation of about 6.5 feet above the harbor zero. The work was filled with stone and decked over, the ends of the deck plank being additionally secured with binding timbers. During the winter a further settling took place to the extent of 2.4 feet in the worst place, as ascertained by levels on June 16, 1892. In order to avoid such excessive sinking of the crib work in the future, with its attendant extra cost for rebuilding, it is proposed to place all work of this class on a pile foundation, and to secure the structure by heavy stone rip rap against being undermined.

Some repairs are needed to the decking, which has been broken in many places during the past winter.

With the working balance of $13,300, available July 1, it is proposed to pay for the repairs of the old breakwater, which are now under way, for repairing the decking of the outer breakwater, partly renewing the filling in the west pier, dredging for the maintenance of the proper entrance depth, and to reserve the rest to be added to the next appropriation for such work as may be authorized hereafter.

For the fiscal year 1894 the estimate is $75,000 for ten additional cribs for the outer breakwater, $8,000 for repairing the old east pier, and $5,000 for other incidental repairs, making, with contingencies, $100,000.

The Light-House Establishment maintains a coast light on the east side of the entrance, and the Life-Saving Service a station on the old east pier near the shore line.

This harbor is included in the collection district of Chicago. The nearest lighthouse is at Michigan City. The nearest port of entry is Chicago, Ill.

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Appropriations for improving harbor at Michigan City, Ind.

Date.	Outer harbor.	Inner harbor.	Total.
July 4, 1836			$20,000.00
Mar. 3, 1837			30,000.00
July 7, 1838			60,733.59
June 11, 1844			25,000.00
Aug. 30, 1852			20,000.00
Mar. 2, 1855 (claim J. R. Bowes)			470.33
June 23, 1866			75,000.00
July 25, 1868 (allotment)			25,000.00
Apr. 10, 1869 (allotment)			31,185.00
July 11, 1870	$25,000.00		25,000.00
Mar. 3, 1871	15,000.00		15,000.00
June 10, 1872	50,000.00		50,000.00
Mar. 3, 1873	50,000.00		50,000.00
June 23, 1874	50,000.00		50,000.00
Mar. 3, 1875	50,000.00		50,000.00
Aug. 14, 1876	35,000.00		35,000.00
June 18, 1878	50,000.00	$25,000.00	75,000.00
1878 (allotment)	2,500.00		2,500.00
Mar. 3, 1879	40,000.00		40,000.00
June 14, 1880	40,000.00	15,000.00	55,000.00
Mar. 3, 1881	20,000.00	25,000.00	45,000.00
Aug. 2, 1882	60,000.00	20,000.00	80,000.00
July 5, 1884	40,000.00	10,000.00	50,000.00
Aug. 5, 1886	54,375.00	1,875.00	56,250.00
Aug. 11, 1888	90,000.00	5,000.00	95,000.00
Sept. 19, 1890	50,000.00	7,500.00	57,500.00
Total	721,875.00	109,375.00	1,118,638.92

Original estimated cost of project for outer harbor, 1870	$324,421.40
Increase by cost of repairs and maintenance to 1882	90,067.10
Project for outer breakwater, including dredging of outer basin, 1882	587,000.00
Total estimates	1,001,488.50
Whole amount appropriated and allotted 1870, to and including act of September 19, 1890	721,875.00
Whole amount expended to June 30, 1892	706,588.95

Money statement.

July 1, 1891, balance unexpended	$42,954.88
June 30, 1892, amount expended during fiscal year	27,668.83
July 1, 1892, balance unexpended	15,286.05
July 1, 1892, outstanding liabilities	1,905.71
July 1, 1892, balance available	13,380.34
Amount appropriated by act approved July 13, 1892	30,000.00
Amount available for fiscal year ending June 30, 1893	43,380.34
Amount (estimated) required for completion of existing project	249,613.50
Amount that can be profitably expended in fiscal year ending June 30, 1894	100,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

INNER HARBOR.

The available depth having diminished to 13 feet at the entrance and to 11 feet in some places in the inner harbor, dredging was commenced at the beginning of September, 1891, and by the end of the year a 70-foot channel 16 feet deep had been excavated from the bend at the inner end of the Government revetments to the entrance, and 50 feet wide and 15 feet deep from the bend to the Michigan Central Railroad bridge.

The dredging plant was thoroughly overhauled and repaired during the winter, and operations were resumed April 22, 1892. Between that time and June 30 the entrance has again been deepened to 18 feet for

a width of 100 feet, the shoal places in the interior navigation have been removed to a depth of 15 feet, and dredging has begun on the extension of the harbor at its inner end towards the railroad crossing, in accordance with the project. The quantity dredged during the year was 84,893 cubic yards.

With the working balance of $2,000 at the beginning of the fiscal year it is proposed to maintain a 13-foot navigation and to continue the extension of the channel at its upper end.

To complete this work will require the removal of 135,000 cubic yards, at an estimated cost of $15,000, to which should be added for repairs and maintenance, $5,000. Total estimate with 10 per cent contingencies, $22,000.

Amount appropriated and expended from 1836 to 1869, inclusive	$287,388.92
Original estimated cost of project for inner harbor, 1870, revised in 1892	131,375.00
Whole amount appropriated, 1870, to and including act of September 19, 1890	109,375.00
Whole amount expended to June 30, 1892	105,923.06

Money statement.

July 1, 1891, balance unexpended	$6,842.51
June 30, 1892, amount expended during fiscal year	3,390.57
July 1, 1892, balance unexpended	3,451.94
July 1, 1892, outstanding liabilities	1,371.96
July 1, 1892, balance available	2,079.98
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	17,079.98
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	7,000.00

COMMERCIAL STATISTICS, MICHIGAN CITY HARBOR, INDIANA.

Entrances and clearances.

Years.	Number.	Revenue collected.	Tonnage.
Fiscal year:			
1885	1,334	$116.35	.....
1886	966	90.10	.....
1887	1,099	.....	213,686
1888	1,167	.....	213,074
Calendar year:			
1888	1,153	.....	208,617
1889	795	.....	169,193
1890	921	.....	172,817
1891	837	.....	168,654

Receipts by vessels, 1891.

[Compiled from statements by John M. Clark, collector of customs.]

Articles received.	Quantity.	Tons.
Coal ... tons	.....	8,255
Lath ... M	14	4
Lumber ... M. feet, B. M.	78,953	137,996
Posts ... number	122,667	2,453
Salt ... barrels	106,054	14,848
Slabs ... cords	246	648
Shingles ... M	62,444	7,806
Stone ... tons	.....	470
Total	.....	172,477

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K K 17.

[Printed in House Ex. Doc. No. 197, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF GRAND RIVER, MICHIGAN, BELOW GRAND RAPIDS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., November 12, 1890.

GENERAL: The preliminary examination of Grand River, Michigan, from Grand Rapids to Grand Haven, called for by circular letter of September 20, 1890, from the office of the Chief of Engineers, has been made, and in pursuance of the requirements of the act of September 19, 1890, I beg to report that in my judgment the river between the designated points is "worthy of improvement" as a commercial highway. The main facts upon which this opinion is based are given somewhat at length in my report of March 22, 1890, a copy of which is forwarded for incorporation herewith.*

A summary of the main points of this report and of other papers of record and relating thereto is as follows:

1. In the case of *The Daniel Ball* (quoted in 10 Wallace, 557; also in Parke's Sup. Ct. Decisions, 69) the United States Supreme Court declares the national character of the navigation as follows:

(5) Grand River, in Michigan, held to be a navigable water of the United States from its mouth, in Lake Michigan, to Grand Rapids, a distance of 40 miles, being a stream capable of bearing for that distance a steamer of 123 tons burden, laden with merchandise and passengers, and forming by its junction with the lake a continued highway for commerce, both with other States and with foreign countries.

2. Surveys and examinations of Grand River were authorized by the river and harbor acts of 1880, 1886, 1888, and 1890, and appropriations aggregating $50,000 were made for its improvement by the river and harbor acts of 1881, 1882, and 1884. Congress, therefore, has repeatedly recognized the status and importance of the stream as a national water way.

3. Following my report of March 22, 1890, and the preparation of a chart of the river from a new survey made by the Board of Trade of Grand Rapids, The Board of Engineers in New York, to which the subject was referred by the Chief of Engineers, reported, under date of April 12, 1890, that the river is "worthy of improvement" and may be deepened by dredging so as to give 6 or 8 feet to Grand Rapids; also that 10 feet or more can be obtained by the same means, although the use of a lock and movable dam might be more economical. Additional information as to the topography and geology of the river valley being needed for the determination of this and other important questions, a copy of this report† and the accompanying letters from the

* Omitted; printed in Annual Report Chief of Engineers for 1890, pages 2676-2681.

† Omitted; printed in Senate Ex. Doc. No. 104, Fifty-first Congress, first session, and in Annual Report Chief of Engineers for 1890, pages 2681-2682.

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Chief of Engineers* and the Acting Secretary of War* is forwarded herewith.

4. As is shown by the accompanying statement, dated November 8, 1890, from the Grand Rapids Board of Trade, it is evident that the commercial interests concerned in the improvement of the river are of great magnitude and that the value of water communication with other lake ports and the country generally would amount to a large sum annually.

5. From the data furnished by the official surveys and reports and the personal examinations made, it is found that the natural features of the stream furnish indications favorable to its improvement; nor have any been so far disclosed as to discourage a reasonable expectation of its conversion into a valuable water way.

The low-water navigation is already one practically of 4 feet. The variations in width are moderate; the banks for the greater portion of the upper part are firm and with an elevation of from 4 to 6 feet above low water; the lower portion of the river, for one-half its length, is practically at the lake level and the slope of the upper portion varies from 3 to 6 inches to the mile. The discharge of the river at low water, while moderate, is sufficient to fill a channel of 8 to 10 feet with a navigable width.

6. The case is evidently one worthy of thorough investigation to cover the points needed for a final determination of the extent to which the navigation can be improved and the best means and cost of effecting it.

In my report of March 22, 1890, I estimated the cost of a thorough examination at $8,000, which the survey made by the Grand Rapids people would reduce by about $3,000. I am now of opinion that, with $4,000 available for the survey, all the information necessary to the final determination of the matter can be procured, including a project and estimates.

For convenient reference there is forwarded herewith a reduction† from the large map of the Grand Rapids survey, showing the main features of the stream.

Respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers, Bvt. Lieut. Col., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. O. M. Poe, Corps of Engineers, Division Engineer. Northwest Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
Detroit, November 14, 1890.

Respectfully forwarded.

As a report of preliminary examination these papers seem to me to be exhaustive. I have personally examined the river, as well as it could be done in one day, and concur in the opinion of Major Ludlow, that it is worthy of improvement.

I therefore recommend that his project and estimate for a survey and examination be approved.

O. M. POE,
Col., Corps of Engineers, etc.,
Engineer Northwest Division.

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* Omitted; printed in Senate Ex. Doc. No. 104, Fifty-first Congress, first session.
† Not printed.

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LETTER OF THE GRAND RAPIDS BOARD OF TRADE.

GRAND RAPIDS BOARD OF TRADE,
Grand Rapids, Mich., November 8, 1890.

DEAR SIR: In reply to your favor of October 31, requesting data relating to the improvement of Grand River, allow me to present the following facts and figures:

1. The population of the city of Grand Rapids as shown by the recent census was 64,147—the population of the so-called half-mile strip, north, east, south, and west, which at the next session of the legislature will be added to the city, is 10,364 or a total of nearly 75,000—having more than doubled our population in ten years.

2. The statistics gathered by the board will show that this city is preëminently a manufacturing town, having 949 manufacturing establishments of all descriptions, producing goods to the value of $28,842,468 per annum ($6,768,000 of the above is furniture).

3. Our furniture finds a market in every State of the Union and many foreign countries, our factories in that branch of industry being the largest in the world.

4. Since the enactment of the interstate-commerce law, railroad freight rates to the West have been largely increased, forcing our manufacturers in sharp and, in several instances, ruinous competition with centers situated on our lakes and navigable rivers, compelling some to remove their plants to cities where water communication with Lake Michigan was had, and some to change their line of manufacture. Iron industries, having their attention called to our city through its well-earned reputation in the wood-working lines, have passed us by, needing cheap water transportation, at least for their raw material, and have located at lake ports. The hard-wood lumber, of which we at present use 28,000,000 feet annually, becomes each year more difficult of access by railroad and the fine oak timber lands in Manistee, Benzie, Antrim, Charlevoix, and other counties in northern Michigan are rapidly invaded by manufacturers from Chicago, Milwaukee, Kenosha, Racine, Cheboygan, and other manufacturing cities situated on the opposite shore of Lake Michigan, and we, for the want of water communication, are powerless to claim our share of this wealth so much needed for our future prosperity.

5. The jobbing trade with an investment of about $4,000,000 feels the need of low-water transportation to meet the favored competitors of Detroit, Chicago, and Milwaukee.

We need more jobbing houses to meet the demand of the rapidly growing towns of northern Michigan and of the upper peninsula. Capital for investment in such enterprises is ready, provided it can get their wares from the eastern markets and from foreign countries by an all-water route.

Grand Rapids is a port of entry and we import direct.

6. That the manufacturing and commercial interest of Grand Rapids is growing, notwithstanding our many difficulties, is evidenced in the fact that the combined tonnage of our railroads and one small river steamer for 1889 was 1,120,823 tons as against 688,000 tons for 1888, and the year's business from data at hand to date will show still a larger amount.

The passenger traffic for 1889 over these lines shows 309,226 persons in and out. These figures are obtained by us from the official records furnished our board by the railroad companies.

7. The future of our city will depend largely on such improvement of our river as will permit lake vessels to load and discharge freight at our port. Every business man of the city is alive to that project. The counties of Ottawa and of Kent, through their Representatives, have indorsed this scheme by suitable resolutions presented to Congress. Rapidly growing northern and western Michigan and the upper peninsula are depending on Grand Rapids for a market, and their newspapers have seconded our efforts to that effect. The jobbing interest, with but a small increase of capital, has increased its sales from $12,489,500 in 1887 to nearly $16,000,000 in 1889, showing more than anything else the growth of such sections of our State as look to Grand Rapids for their supplies. Hard-wood timber lands being cleared becomes fine farming land and is taken up as fast as it is put on the market. Manufactories of various kinds in woodenware have for the past two years been started in towns north of here and are successfully operated, all tending to large increase of population and depending on Grand Rapids for support.

This all will show the probability of large increase of freight and passenger traffic at Grand Rapids, and it is fair to presume that the increase shown in 1889 over 1888 will hold good for the next ten years to come, which will give us a tonnage in 1900 of 5,500,000.

But, anticipating some depression and bad years of business and assuming that the average annual increase will be only 200,000 tons (which is one-half of the 1889 increase), we will still show a tonnage in 1900 of over 3,000,000, making the average for next ten years 2,300,000 tons.

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With an average saving of only 1 cent per 100 pounds on this traffic it represents the enormous amount of $460,000 per year that would be saved in freight alone going in and out of Grand Rapids.

If any other information you may require, I shall be glad to furnish it.

Respectfully yours,

H. D. C. VAN ASMUS,
Secretary.

Maj. WILLIAM LUDLOW,
Corps of Engineers, U. S. A.

SURVEY OF GRAND RIVER, MICHIGAN, BELOW GRAND RAPIDS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., April 11, 1892.

GENERAL: I have the honor to submit a report, with accompanying papers, maps, etc., on the survey of Grand River, Michigan, from Grand Rapids to Grand Haven, as authorized by the act of September 19, 1890, in the following terms:

Grand River below Grand Rapids, with a view of determining the existence or nonexistence of underlying rock, the hydraulics of the river, and the detailed topography of the valley subject to overflow.

Grand River, the largest in the State and the main affluent of Lake Michigan, drains the heart of the lower peninsula, with a watershed stretching across to within 40 miles of Lake Erie and covering some 5,700 square miles of territory. At the mouth of Grand River, on the east shore of Lake Michigan, is the town of Grand Haven, whose harbor has always been an important harbor of refuge by reason of its capacity and depth, due to the large discharge of the stream. Forty miles up the river, at the head of navigation, is the city of Grand Rapids, an exceptionally thriving center of population and industry, whose products, particularly furniture, reach the markets of the world.

Between Grand Haven and Grand Rapids the river is navigable for light-draft vessels, the depths diminishing from 4 fathoms in the harbor to 4 feet in the upper reaches, with a few bars of less depth at minimum stages, and this navigation it is proposed, if practicable, to deepen and maintain in order that the full capacity of the stream for water transportation may be developed. The question therefore resolves itself into (1) the extent to which the physics of the stream and its valley will admit of betterments of the existing transportation facilities, (2) the means best adapted to this end, and (3) the cost of securing them.

For a better understanding of the general and special aspects of the matter, its official history may first be summarized.

The status of the navigation in question was adjudicated by the Supreme Court of the United States in the case of *The Daniel Ball* (10 Wallace, 557), as follows:

Grand River, in Michigan, held to be a navigable water of the United States from its mouth in Lake Michigan to Grand Rapids, a distance of 40 miles, being a stream capable of bearing for that distance a steamer of 123 tons burden, laden with merchandise and passengers, and forming by its junction with the lake a continued highway for commerce both with other States and with foreign countries.

The act of June 14, 1880, authorized a survey and examination of the navigable section, a report of which was submitted under date of February 12, 1881.

Transit lines were run on both banks from Grand Rapids to the lower end of the Ottawa boom, a distance of 33 miles, and a line of levels on the north bank from Grand Rapids to Spoonville, 29 miles, with lines

of soundings across the river 300 to 500 feet apart and gauge readings at four points.

The chart and profile, reduced to a low-water plane, showed that the total fall from Grand Rapids to Grand Haven was about 6 feet, practically concentrated in the stretch from Grand Rapids to Lamont (19 miles), below which the level was approximately that of the lake, 20 miles distant. From Grand Rapids to Grandville (6 miles) the fall was 3 feet, with a slope of 6 inches to the mile, and from Grandville to Lamont (13 miles) the fall was 3 feet, with a slope of 3 inches to the mile.

From Grand Rapids to Bass River (23 miles) the natural navigation gave 4 and 6 feet low-water draft, with a few bars of less depth, and from Bass River to the Ottawa boom (10 miles) the natural navigation was 6 and 8 feet, and thence to Grand Haven 10 feet and more.

The cost of dredging with the facilities for such work then existing was large, and at 30 cents per cubic yard the estimate for an 8-foot navigation by dredging and wing dams was about $750,000.

The act of March 3, 1881, appropriated $10,000 toward an improvement of the river; that of August 2, 1882, $15,000; and that of July 5, 1884, $25,000; which sums were mostly expended in deepening the upper reaches by dredging; but the contract cost was excessive, ranging from $1 to 25 cents and 30 cents per cubic yard, and the net results were thereby correspondingly reduced.

It is to be noted, as indicating the nature of the river bed and the possibilities of maintaining a dredged channel, that the materials excavated and deposited near the line of the improvement are still in place.

The subsequent acts of August 5, 1886, and August 11, 1888, authorized further examinations, that of 1888 for the first time declaring the character of navigation called for, viz: "a channel of navigable width and minimum depth of 10 feet."

With reference to this, after personal inspection of the river and careful examination of the records, maps, etc., I made report under date of March 22, 1890, from which the following is taken:

From the data of record a general view of the situation can be had and some leading facts become evident.

There has been on the part of the commercial interests of Grand Rapids a strong and well-sustained endeavor to secure, if such a thing be possible, adequate water communication with Lake Michigan, and in the absence of the means of forming a just conception of what is practicable, their demands have gone to the fullest limit of possibility. Grand Rapids has apparently gauged her navigation requirements by the ample measure of her own development and commercial standing, and insisted that the river should be made to fulfill them, as is indicated in Major Harwood's original report, where reference is made to the desire for means of making shipments of Grand Rapids products direct to Europe without breaking bulk. In the course of such a project as this there are more obstacles than the inadequate capacity of Grand River.

The commercial statistics for the year 1887 state the number of operatives in the 380 factories at 11,110, the capital employed at $15,216,400, and the value of the annual product at $24,048,800. Such industries as these can not wisely be discouraged, and if the difference in cost between rail and water freights—the latter averaging about one-half the former—be taken into account, the annual value of water communication, both to Grand Rapids and to the country generally, with which extensive dealings are had, must amount to a large sum.

The information furnished by the surveys, one of 35 miles from Grand Rapids in 1880, and one of 11 miles in 1884, leaves several important points to be covered before final conclusions can be reached as to the actual capacity of the stream and the possible extent to which it can be improved.

The velocity, volume, and discharge of the river are not known, nor the limits within which these vary at different seasons of the year and in different years.

The nature of the banks and bed has not been fully explored so as to determine the quantity and character of material that must be dealt with, whether by dredging, by revetments and wing walls, or by lock and dam, or by all these combined if needful.

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The topography of the lowlands in the valley of the stream still remains to be disclosed to show how much of these would be affected, and to what extent, by an artificial elevation of the surface, as compared with the annual floods and high-water stages of the river.

When these facts are known, it will then be possible to estimate, as has not yet been done, the cost of a permanent improvement of the river so as to afford a navigation of 6, 8, or 10 feet, and until this information shall have been obtained and thoroughly considered, the questions what best to do and what it will cost to do it must remain matters of speculation.

Some considerations relative to this matter, and not heretofore stated, may be mentioned. Grand River is the largest in the State of Michigan, and has a watershed of, roughly, 5,775 square miles. The average rainfall at Grand Haven, according to the Signal Service records, is 37.65 inches. Over the entire drainage area, therefore, the rainfall averages 16,019 cubic feet per second. If 70 per cent of this be allowed for evaporation, absorption, etc., there will remain 30 per cent, equal to 4,806 cubic feet per second, to be discharged by the river. Assuming a velocity of $2\frac{1}{4}$ miles per hour, equal to $3\frac{3}{4}$ feet per second, this average discharge would fill a channel of $\frac{4806}{3\frac{3}{4}} = 1{,}311$ square feet cross section; so that if made trapezoidal, with banks of one-half and a bottom width of 50 feet, the channel would be 16 feet deep at the mean stage, with a surface width of 114 feet. If the low-water discharge of the open river be assumed at one-fourth of the mean discharge, and the velocity at low stage be assumed at $1\frac{1}{2}$ miles per hour, equal to 2.2 feet per second, the river will fill a cross-sectional area of $\frac{1201}{2.2} = 546$ square feet, and the 50-foot channel would have a depth at low stage of 8.2 feet.

These computations are given, not as facts, though probably fair approximations from general data, but as indicating the need of further information to verify or correct them.

Reverting to more general considerations, it does not appear, even supposing it impracticable at any reasonable cost to establish a water way of such capacity as freely to admit the largest class of lake vessels, that a less depth would not be of service.

The ruling draft for deep-water lake navigation is 15 feet, although many vessels now built and building are ready to load to 17 feet as soon as sufficient depth of water way can be secured, and the prospect is that 20 feet, as at the new Sault Ste. Marie Lock, will presently be sought for. But a very large proportion of the lake business is done on much less draft. The trade of numerous ports is conducted with 8 and 10 feet, and side-wheel vessels are abundantly able to carry heavy cargoes on 6 and 7 or even 5 feet of water. The Erie Canal has 7 feet; the Canadian canals were built for 4 and $4\frac{1}{2}$ and later deepened to 9 feet. These works, the outlets for lake commerce, have cost millions of dollars, but no one questions their compensating value in the movement of heavy freights, the marketing of products, and the reduction in the cost of transportation. The Ohio River improvement is based on securing a navigable draft of 7 feet at an estimated cost approximating to $70,000,000. The Mississippi and Missouri are seeking improvement to 5 feet in the upper portions and to 8 and 10 in the main stream. The Great Kanawha improvement is designed to secure 6 or 7 feet for a distance of 96 miles at an estimated cost of $3,000,000; 5 feet is wanted for 100 miles of Elk River, and 4 feet in the Fox and Wisconsin. The Cumberland and others are striving, with an expenditure of millions, to get 3 feet.

Illustrations on these points could readily be multiplied, but the facts are well known to those conversant with the general subject of river improvement and need not be recounted. There is no doubt as to the commercial value of an 8 or even 6 foot navigation where the business, actual and potential, is such as to warrant it, and the evidence seems by no means conclusive as to the impracticability of securing these or greater depths in Grand River. In fact, there are certain conditions quite favorable to the improvement of the stream.

The river at present is practically in a state of nature, no attempt having been made to control or regulate it, and it can not be considered that the removal of a few bars to open a 4-foot navigation furnishes a conclusive test of its ultimate capacity for improvement. The slope of the river in its section of maximum low-water inclination, viz, the upper 6 miles between Grand Rapids and Grandville, is about 6 inches to the mile, and in the adjacent section of 13 miles to Lamont is about half that. For the remaining distance of 21 miles from Lamont to Grand Haven there is no slope at all. Through this lower stretch of 21 miles, therefore, the navigation can be deepened to any desired extent without disturbance of its regimen, and the maximum slope of the upper section does not exceed that found in numerous other streams already navigable.

The information as to the character of the bed and banks of Grand River is such as to indicate considerable stability. The material dredged consisted largely of

bowlders, clay, shingle, and gravel, with a moderate proportion of sand. Dredge cuts through these can not again fill with the same materials, and there are no indications of any considerable transportation of sand by the current. The existence of the dam at Grand Rapids prevents this from the upper river.

The logging industry of Grand River is practically at an end. There is but one more run of logs to come out and the supply will be exhausted. A log jam can not again occur, and the 2½ miles of "boom" that has preëmpted the best part of the river at the head of the deep-water navigation can be removed and the river again devoted to more general navigation uses.

In compliance, therefore, with the requirements of Department indorsement of March 12, I beg leave to say that, in the language of the act of August 11, 1888, I regard Grand River as worthy of improvement by the General Government for the reasons—

(1) That Congress has in six several acts recognized its status and importance as a water way by three appropriations aggregating $50,000, and by repeated orders for its examination.

(2) That the commercial interests concerned in the matter are very large and actually existent, and the annual money value of an effective improvement would amount to a considerable sum.

(3) That there is practically a natural low-water navigation of 4 feet to begin with, and the physics of the stream, as so far ascertained, present no insuperable obstacles to its regulation, control, and conversion into a valuable water way, and indicate the existence of none, other than such as in numerous cases have been encountered and successfully overcome.

(4) That whatever may hereafter be determined as to the practicability and best means of making the improvement, the case is one that is worth at least a thorough investigation, upon which to base final conclusions as to the character and cost of the necessary works and constructions.

To do this I estimate that the expense of the investigation, to cover all points and conclude the matter, will probably amount to $8,000, and am of opinion that the expenditure of this amount is warranted by the circumstances of the case.

It is understood that the Grand Rapids Board of Trade has recently completed a resurvey of the river from Grand Rapids to the mouth, with transit and level lines, soundings, gaugings, etc., at a cost of $3,000, which information will be of value in connection with any future consideration of the subject, and to that extent reduce the cost of completing the investigation.

The subject having been referred to The Board of Engineers in New York, report was made as follows, under date of April 12, 1890:

The new survey, made at the expense of the city of Grand Rapids, has added materially to the information in possession of the Board. Some matters, however, remain to be determined, such as the existence or nonexistence of underlying rock; the hydraulics of the river itself; the detailed topography of the immediate valley subject to overflow, etc. Until these facts are known any opinion on the question submitted to the Board must be held subject to revision.

Grand River can be improved by dredging so as to give 6 or 8 feet navigation up to Grand Rapids at a cost, provided rock is not struck, not exceeding $500,000 for the latter depth as first cost. In consequence of the small low-water flow of the river at Grand Rapids (about 1,091 cubic feet per second) the channel will have to be maintained by dredging, the amount of which can only be determined by experience.

The citizens of Grand Rapids estimate the annual saving on their freights by an improved water communication at $280,000. The present river commerce is small, but with a deeper channel it is probable that enough commerce would be developed to justify the expenditure mentioned above, though the saving would probably be less than that estimated by the citizens of Grand Rapids.

The Board therefore thinks the river "worthy of improvement."

Ten feet or more can also be obtained and maintained by dredging, but the cost would be great, and a lock and movable dam may be more economical. The lock and dam would be more satisfactory, and it is possible that it would be better than dredging even to 8 feet. This question can not be settled except by a survey for the determination of the proper site for such a lock and dam by the local officer, and of the amount of land which may be overflowed.

Pursuant to these reports the act of September 19, 1890, contained provision, as already quoted, for further and more specific examination, and on November 12, 1890, in response to letter from the Chief of Engineers, of September 20, I reported: That the statistics of November 8, 1890, furnished by the Grand Rapids Board of Trade made it evident

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that the commercial interests concerned in the improvement of the river are of great magnitude, and that the value of water communication with other lake ports and the country generally would amount to a large sum annually; that the data already at hand showed the natural features of the stream to furnish indications favorable to its improvement, and to disclose none discouraging a reasonable expectation of its conversion into a valuable water way; and that, allowing for the utilization of the survey and maps made by the Grand Rapids Board of Trade, an expenditure of $4,000 would suffice to complete the investigation of the subject.

These views being concurred in by Col. O. M. Poe, Division Engineer, an allotment of $1,000 from the general appropriation for surveys was made in November, 1890, and an additional allotment of $2,000 in March, 1891; still later, viz, in February and April, 1892, two further allotments of $500 each brought the amount up to the total estimated.

The work to be done was of a special character, specific information being called for in the act without reference to what the progress of the survey might show to be actually necessary, and in particular the ascertainment of the topographical features for accurate determination of the quantity and valuation of such lands as might be subject to overflow in case a dam were constructed, involved thorough exploration of the river valley, which is largely covered with heavy timber and brush, and in addition is at several points occupied by swamps and marshes of considerable extent. This portion of the investigation, which the results show was really unnecessary, was arduous as to the actual field work with transit and stadia from the necessity of removing obstructions to view and progress, and proportionally tedious in the final plotting from the multiplicity and minuteness of the recorded data. Furthermore, the sum available prior to the completion of the field work limited the number of assistant engineers whom it was practicable to employ, and economical considerations imposed the burden of both field work and plotting of the notes upon a single individual.

The detailed operations of the survey are stated in the accompanying report by Mr. Fred Morley, assistant engineer, to which I beg to refer for full particulars, and at the same time take occasion to express my sincere appreciation of the unremitting industry and zeal and the intelligence and thoroughness with which his work has been done.

The projects and estimates given in Mr. Morley's report, made in pursuance of my instructions, have been discussed and considered jointly and have my general concurrence. Care has been taken to secure entirely reliable data, and the computations, etc., have been checked and verified. The volume of the stream is ascertained at a time when from prolonged annual deficiency in precipitation the lake level has fallen 2½ feet since 1886, until it has reached a point lower than the low level of 1872, the lowest heretofore recorded. The discharge and low-water elevation of the river, employed as a basis of computation, are therefore minima, and future conditions in these respects will in all likelihood be more favorable, giving practical results that will either reduce the cost of constructing the channel or increase its relative capacity, as circumstances may hereafter indicate as most advisable. Furthermore, it may be observed, that as the project provides for a 10-foot navigation at the minimum stage, the foot and a half additional depth found during several months of the navigation season correspondingly increases the practicable draft.

In computing the excavation needed for the open channel, full allowance has been made for the reduction in slope of water surface, and

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consequent lowering of the bed of the channel at the upper limits, due to the deepening, the datum slopes being less than half an inch to the mile from Grandville down, and about two-thirds of an inch to the mile from Grand Rapids to Grandville.

The unit prices for material in the estimates are believed to be fairly liberal, and contingencies of 15 per cent are included in the totals. The principal item, of course, is the dredging, which is estimated at 10 cents.

In the case of a project of this magnitude there should be no difficulty in doing the work within this figure. The Government dredging at the harbors on the east coast, with plant of small capacity and moving from point to point, averages less than 10 cents, and in one case a contract for 60,000 cubic yards was made at Portage Lake for that price. When it is a question of handling 3 or 4 million yards, the price, if adequate means and a properly equipped plant are available, should not exceed 7 or 8 cents.

The general conclusions derivable from the data now at hand may be stated as follows:

1. An open 10-foot channel of navigable width can be constructed within a sum the expenditure of which would be warranted by the magnitude of the commercial interests concerned and the economic value of the improved navigation.

2. The construction of a dam in the stream in order to diminish the amount of dredging needed to secure a 10-foot navigation will not reduce the total cost of the project, and the objection thereto, viz, cost of operation and maintenance and interference with free movement of vessels and flow of water, as well as possible claims for land damages, are not counterbalanced by any economic advantages.

3. The reduced cost of the 8-foot open channel is not sufficient to offset the restriction in navigation facilities.

4. It is probable that at some points permanent works in the bed of the stream may hereafter be found advisable to regulate the movement of the water, and an allowance is made in the estimates for these constructions.

It is evident, however, that such permanent works should not be built until the approximate corrected regimen of the river shall have been established, and prolonged observation and experience under the altered conditions of discharge clearly prove their necessity and indicate the sites and methods to be adopted in building them.

5. The estimated cost of the three comparative projects is as follows:

1. For the open 8-foot navigation	$463,450
2. For 10-foot navigation with lock and dam	673,880
3. For the open 10-foot navigation	670,500

These totals in each case include a sum of $169,000 as a preliminary estimate for wing dams, etc. It is entirely possible that much of this cost will be found unnecessary, but it is considered proper to introduce the item.

I recommend the adoption of the last project and that an appropriation of $100,000 be made for beginning the work.

If practicable the total sum required should be placed at the disposition of the Engineer Department, to be drawn against in annual sums as should be needed, in order that the completion of the work should be provided for without suspension from lack of funds, and contracts be made for the full amount of work to be done. By this means costly delays would be avoided, and advantage could be taken to procure the services of a thoroughly equipped and effective plant, under conditions favorable to economic and engineering results.

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It may be stated, in conclusion, that the reduction of level at Grand Rapids, due to the deepening of the navigation to 10 feet, and producing an additional head at the dam of about 4½ feet at low stage, may be turned to account for industrial purposes, but independently of this will be advantageous in giving better fall to the sewer system of the city, and in reducing the probabilities and damage from floods in the valley or the gorging of ice in the spring.

Very respectfully,

WILLIAM LUDLOW,
Major, Corps of Engineers,
Bvt. Lieut. Col., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. FRED. MORLEY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., April 9, 1892.

SIR: I have the honor to submit the following report of the survey of Grand River, Michigan, from Grand Rapids to Grand Haven, assigned to me by your letter of June 3, 1891, together with considerations looking to the improvement of the river so as to obtain a 10-foot navigable channel from Lake Michigan to Grand Rapids.

FIELD OPERATIONS.

The field operations are comprised under the following heads, viz:

1. A topographical survey of the river valley.
2. Borings in the bed of the river.
3. Discharge observations.

I.—SURVEY.

After an examination of the maps and records of former surveys and a preliminary examination of the river, it was thought unnecessary to make a topographical survey of the river valley below the mouth of Bass River, which is about 23½ miles below Grand Rapids The survey was made with the transit and stadia. Work was begun July 1, 1891, at Fulton Street Bridge in Grand Rapids under my immediate charge. I was assisted by a recorder, three stadiamen, and an axman. The survey was carried about 24 miles below the point of beginning, and was completed, including discharge observations, on September 10, 1891.

In this stretch of river the immediate banks of the stream are mostly high, frequently presenting the appearance of levees, and in the upper half of the stretch the country lying between the banks and the foothills, though frequently lower than the banks, is almost everywhere considerably above the low-water surface of the river. In the lower half of this stretch bayous and low swamps are common between the river bank and the foothills on one or other side of the river. The valley as a whole is, however, comparatively narrow, and bluffs from 50 to 60 feet in height occasionally come close to the bank. In making the survey, in order to determine a contour from 10 to 12 feet above low-water surface, it was usually found necessary to run a stadia line along each bank and an additional one on either side next the foothills or back of swamps and bayous.

To preserve on the ground traces of the survey for future reference, posts about 6 inches in diameter, sharpened at the top, were set about 2½ feet in the ground. These posts were used as stations on the survey, and were so situated that each succeeding one could be seen from the preceding one. They each project from a foot to a foot and a half above ground, and are located near the bank of the river. The number of each is inscribed upon it and upon a witness tree near by. Azimuths were read around to the right from magnetic south at stadia one at Grand Rapids. The magnetic variation was not determined, but is probably about 1° 20′ E. For the purpose of checking the azimuths the various stadia lines were closed upon each other at intervals. No levels were taken, but the various bench marks established along the river in former surveys were used as a check on elevations.

The bench marks of former surveys mentioned above are distributed along the river at various intervals, and are mostly on roots of trees. They are mainly of the surveys of 1884 and 1889. Levels had been run between these benches two and fre-

quently three times, the results of which differed somewhat. Before beginning the survey, therefore, an adjusted or most probable value for the elevations of the benches was determined, and these most probable elevations used.

The datum plane of reference in the surveys of 1884 and 1889 is 100 feet below the "top of water table of Rindge, Bertsch & Co.'s store, corner of Pearl and Campau streets, Grand Rapids, the point taken being on the Pearl street side, 1 foot and 9 inches from the Campau street side." All elevations in the present survey have been referred to the same datum. The datum plane of reference for the city of Grand Rapids is 76.08 feet higher than the above datum.

II.—BORINGS.

Beginning at the Fulton Street Bridge, in Grand Rapids, borings were made in the river bed for about 32 miles. For the remaining 7 miles, to the mouth at Grand Haven, more than a 10-foot channel already exists, and no borings were necessary in this part of the river. Ninety-two borings were made in all, decreasing in frequency down river. For the first 6 miles the average number of borings per mile is five; for the next 9 miles the average is three, and for the remaining 17 miles the average is two per mile.

The borings were made from a flatboat or raft 20 feet long by 10 feet wide and about 14 inches deep. The boat was provided with spuds at the corners for anchoring it and keeping it steady while at work. A well hole about 8 inches square was made in the middle of the boat for working the tools through.

Four sections, from 3 to 5 feet in length, of extra heavy 2-inch (internal diameter) steel piping with strong couplings were procured. A strong steel annular shoe, slightly larger in external diameter than the pipe and formed with a cutting edge, was screwed to the lower end of the lower section. On the upper end of the upper section was screwed a strong steel driving-head. To make a boring the pipe was placed vertically through the well-hole in the boat and driven by sledges handled by two laborers. The blows were transmitted to the steel head through a wooden block bound with iron rings and held in place. As the pipe descended under the action of the blows, it was turned around by a pipe-wrench. When occasion required the head was unscrewed, another length of pipe introduced, the head screwed to the top of the new length, and the driving continued. To withdraw the pipe a derrick was placed on the boat with its top vertically over the well-hole. Power was exerted through a windlass with ordinary wagon wheels attached for applying hand power, and a 3-sheaved block and tackle for further multiplying the hand force.

With this arrangement no serious difficulty was experienced in withdrawing the driven pipe. In most cases it was possible to drive the pipe to the desired depth without withdrawing it in the process, but in hard material in order to reach the required depth it was sometimes found necessary after driving the pipe to refusal to withdraw it, remove the material collected within the pipe, replace it, drive again, and so on. Sometimes the required depth was reached by introducing within the 2-inch pipe a smaller pipe with a drill attached, and the hole continued by churning the latter. A large number of specimens of material brought up in the 2-inch pipe were preserved for record.

The depths of the borings vary from 13 to 15 feet below water surface at the time they were made, which was at a low stage of the river. As those in the upper part of the river have a depth of 15 feet, it will be seen that the borings give a knowledge of the material underlying the river bed for about 10 feet below the water level of Lake Michigan. At the time of making the borings their locations were determined by measurements to stakes on the shore or by ranges. A stake was also set with its top 1 foot above water surface. Afterwards the location and elevation of these stakes were determined by the stadia with reference to points of the survey. The location of the borings, and the elevation of their bases, or of the different strata of material found, thus become known.

At Clam Shell Bar, 5 miles below Grand Rapids, very hard material was found at 10 feet below water surface, and at 12 feet, or at an elevation of 59.6, plaster rock was struck. This rock does not extend for more than 1,000 feet in the direction of the river, and as it is almost wholly below any contemplated dredging, and is a soft rock, it is hardly worth noting. At no other place was rock found. In the upper 8 miles gravel and clay predominate and below this sand.

The first boring was made August 26, and the last on September 23. For want of a small boat, the most of the borings in the upper reach were made near the shore, and at no place was especial pains taken to make the borings in the deepest water. It is believed that this does not detract from the reliability of the information obtained from them, as it is not likely that the character of the material would change for 100 feet or so either side of the channel. These borings have been plotted on the map of the survey and a sectional representation of them has been prepared, from which full information of the material met with in the bed of the river may be obtained at a glance.

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Record of the borings.

No.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Distance from foot of Ganoes canal.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.*	
	Boring 0:					Above.	
1	Water	2.0	2.0	75.3	Aug. 26	3,222	Located near S. W. cor. of center pier of Fulton St. Bridge.
2	Small stones, coarse gravel, and fine sand mixed.	14.7	12.7				
	Boring 1:					Below.	
1	Water	2.9	2.9	74.7	Aug. 28	125	Struck bowlder at 7.4 ft. Near left bank.
2	Fine gravel and coarse sand	3.4	0.5				
3	Fine sand changing to blue clay.	6.7	3.3				
4	Quicksand	7.2	0.5				
5	Blue clay	7.4	0.2				
	Boring 2:						
1	Water	4.0	4.0	74.7	Aug. 28	125	Near left bank.
2	Fine gravel and sand, changing to blue clay.	6.5	2.5				
3	Quicksand	7.0	0.5				
4	Blue clay (hard)	13.6	6.6				
	Boring 3:						
1	Water	1.9	1.9	74.7	Aug. 29	1,375	Do.
2	Coarse gravel and sand	7.6	5.7				
3	Small stones and fine sand	9.0	1.4				
4	Blue clay (hard)	14.4	5.4				
	Boring 4:						
1	Water	3.2	3.2	74.5	Aug. 29	2,492	Located near left bank.
2	Mud	3.4	0.2				
3	Blue clay (hard)	15.0	11.6				
	Boring 5:						
1	Water	3.9	3.9	74.4	Aug. 31	3,830	Near left bank.
2	Medium fine sand mixed with blue clay (soft) 4 to 1.	16.5	12.6				
	Boring 6:						
1	Water	4.9	4.9	74.4	Aug. 31	5,470	Near left bank and above mouth of Plaster Creek.
2	Coarse gravel and sand	10.0	5.1				
3	Fine sand and blue clay	15 5	5.5				
	Boring 7:						
1	Water	2.5	2.5	74.1	Sept. 1	6,575	Near dredge dump in river. Struck bowlder at 11.6 ft.
2	Fine gravel and sand	10.0	7.5				
3	Medium coarse gravel and sand.	11.6	1.6				
	Boring 8:						
1	Water	2.5	2.5	74.1	Sept. 1	6,590	Struck bowlder at 12.6 ft.
2	Fine gravel and sand	10.0	7.5				
3	Medium coarse gravel and sand	12.6	2.6				
	Boring 9:						
1	Water	2.5	2.5	74.1	Sept. 1	6,477	Located near dredge dump in river.
2	Fine gravel and sand	10.0	7.5				
3	Medium coarse gravel and sand	13.0	3.0				
4	Gravel and sand mixed with clay.	16.1	3.1				
	Boring 10:						
1	Water	4.0	4.0	74.2	Sept. 2	7,815	Located near old dock above lower Plaster Mill.
2	Gravel and fine sand	9.0	5.0				
3	Blue clay (soft) mixed with stone and sand.	16.0	7.0				
	Boring 11:						
1	Water	2.4	2.4	73.7	Sept. 2	9,368	Near right bank.
2	Fine sand, shell, and gravel	5.0	2.6				
3	Fine white sand	7.5	2.5				
4	Sand and very coarse gravel	12.0	4.5				
5	Tough yellow clay and stone	14.8	2.8				
	Boring 12:						
1	Water	4.0	4.0	73.7	Sept. 2	10,328	Near right bank. Struck bowlder at 7.6 ft.
2	Sand and gravel	7.6	3.6				
	Boring 13:						
1	Water	4.0	4.0	73.7	Sept. 2	10,328	Located 6 ft. from No. 12.
2	Sand and gravel	16.0	12.0				
	Boring 14:						
1	Water	3.0	3.0	73.7	Sept. 3	11,913	Near left bank at mouth of creek.
2	Mud	2.5	0.5				
3	Blue clay (hard) and stone	10.0	6.5				
4	Yellow clay (soft) and sand	14.0	4.0				
	Boring 15:						
1	Water	2.8	2.8	73.5	Sept. 4	13,383	Near left bank just below L. S. & M. S. R. R. bridge.
2	Fine yellow sand	4.5	1.7				
3	Medium coarse gravel	11.0	6.5				
4	Coarse gravel and yellow clayey sand.	15.6	4.6				

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Record of the borings—Continued.

No.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Distance from foot of Ganoes canal.	Remarks
		Feet.	*Feet.*	*Feet.*		*Feet.* Below.	
	Boring 16:						
1	Water	2.3	2.3	73.4	Sept. 4	15,010	Near right bank.
2	Fine sand	15.0	12.7				
	Boring 17:						
1	Water	2.4	2.4	73.3	Sept. 5	15,903	Near mouth of creek on right bank.
2	Yellow clay and sand mixed	10.0	7.6				
3	Sand and coarse gravel	15.0	5.0				
	Boring 18:						
1	Water	2.5	2.5	72.8	Sept. 5	16,852	Located near right bank.
2	Sand, shell, and reddish clay	11.5	9.0				
3	Coarse gravel	13.6	2.1				
4	Gravel and white sand	14.3	0.7				
	Boring 19:						
1	Water	3.0	3.0	71.9	Sept. 5	18,670	Near left bank at mouth of creek.
2	Mud	4.0	1.0				
3	Sand	9.5	5.5				
4	Very coarse gravel and sand	15.0	5.5				
	Boring 20:						
1	Water	1.7	1.7	71.9	Sept. 8	19,906	Near right bank a spring creek.
2	Fine sand	5.0	3.3				
3	Sand, gravel, and shell	6.5	1.5				
4	Blue clay (hard)	14.8	8.3				
	Boring 21:						
1	Water	3.7	3.7	71.9	Sept. 8	21,664	Near right bank.
2	Sand	5.0	1.3				
3	Blue clay (hard)	12.0	7.0				
4	Blue clay (hard), sand, and gravel.	14.8	2.8				
	Boring 22:						
1	Water	4.0	4.0	72.0	Sept. 8, 9	22,905	Located at mouth of creek, right bank. Too hard to drive farther.
2	Sand	6.0	2.0				
3	Yellow clay	8.0	2.0				
4	Gravel and clay (hard)	12.0	4.0				
	Boring 23:						
1	Water	4.0	4.0	72.0	Sept. 9	22,911	6 feet below boring 22.
2	Sand	6.0	2.0				
3	Yellow clay	8.0	2.0				
4	Clay, sand, and gravel mixed (very hard).	15.0	7.0				
	Boring 24:						
1	Water	3.4	3.4	72.0	Sept. 9	24,696	Near right bank.
2	Fine sand	9.0	5.6				
3	Gravel and blue clay (soft)	10.0	1.0				
4	Blue clay (soft) and stone	15.0	5.0				
	Boring 25:						
1	Water	3.7	3.7	71.5	Sept. 10	26,382	Near left bank at Clam-shell bar; rock at 10 ft.
2	Sand	8.0	4.3				
3	Blue clay, sand, and shell mixed (very hard).	10.0	2.0				
	Boring 26:						
1	Water	3.7	3.7	71.5	Sept. 10	26,392	Rock at 10 ft.
2	Sand	8.0	4.3				
3	Blue clay, sand, and shell mixed (very hard).	10.0	2.0				
	Boring 27:						
1	Water	2.5	2.5	71.6	Sept. 11	26,774	Located at right bank at Clam-shell bar.
2	Fine sand	6.0	3.5				
3	Clay	9.0	3.0				
4	Clay and stone (hard)	12.0	3.0				
5	Plaster rock	13.2	1.2				
	Boring 28:						
1	Water	3.8	3.8	71.6	Sept. 11	26,960	Near right bank at Clam-shell bar; rock at 10.8 ft.
2	Fine sand	6.0	2.2				
3	Clay	10.8	4.8				
	Boring 29:						
1	Water	4.5	4.5	71.5	Sept. 11	27,090	Near right bank at Clam-shell bar; rock at 10.02 ft.
2	Sand	6.0	1.5				
3	Blue clay (stiff)	8.0	2.0				
4	Blue clay and gravel	10.2	2.2				
	Boring 30:						
1	Water	4.5	4.5	71.3	Sept. 12	29,257	Near left bank.
2	Sand	14.0	9.5				
	Boring 31:						
1	Water	5.0	5.0	71.3	Sept. 12	31,105	136 ft. from left bank at Grandville.
2	Sand	7.0	2.0				
3	Yellow clay (stiff) and stone	14.0	7.0				

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Record of the borings—Continued.

No.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Distance from foot of Ganoes canal.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.* Below.	
	Boring 32:						
1	Water	3.5	3.5	71.2	Sept. 12	33,380	Located near right bank.
2	Sand	8.5	5.0				
3	Coarse gravel and blue clay mixed.	10.8	2.3				
	Boring 33:						
1	Water	4.5	4.5	71.0	Sept. 14	34,420	Near right bank.
2	Sand	8.0	3.5				
3	Coarse gravel and blue clay mixed.	14.0	6.0				
	Boring 34:						
1	Water	4.5	4.5	70.6	Sept. 14	37,020	Near left bank.
2	Fine sand	14.0	9.5				
	Boring 35:						
1	Water	7.0	7.0	70.8	Sept. 15	38,475	Near left bank.
2	Sand mixed with shell	9.0	2.0				
3	Clay and gravel mixed	14.0	5.0				
	Boring 36:						
1	Water	4.5	4.5	70.7	Sept. 15	40,000	Near left bank.
2	Sand	6.5	2.0				
3	Blue clay and fine sand mixed	12.0	5.5				
4	Gravel and fine sand	14.0	2.0				
	Boring 37:						
1	Water	3.0	3.0	70.5	Sept. 15	42,000	Near left bank.
2	Sand	5.0	2.0				
3	Sand and clay mixed	7.0	2.0				
4	Blue clay (soft)	12.0	5.0				
5	Clay and gravel mixed	14.0	2.0				
	Boring 38:						
1	Water	3.5	3.5	70.4	Sept. 15	44,285	Near right bank.
2	Sand	14.0	10.5				
	Boring 39:						
1	Water	4.5	4.5	70.1	Sept. 16	47,152	Located near left bank.
2	Sand	14.0	9.5				
	Boring 40:						
1	Water	6.0	6.0	70.0	Sept. 16	48,810	Near left bank.
2	Sand	14.0	8.0				
	Boring 41:						
1	Water	4.0	4.0	69.9	Sept. 16	50,716	Near right bank.
2	Sand	6.0	2.0				
3	Fine gravel and sand	14.0	8.0				
	Boring 42:						
1	Water	6.0	6.0	69.9	Sept. 16	52,712	Near right bank at sand hills.
2	Sand mixed with shell	14.0	8.0				
	Boring 43:						
1	Water	4.4	4.4	69.8	Sept. 16	54,828	Near right bank.
2	Sand	14.0	9.6				
	Boring 44:						
1	Water	3.2	3.2	69.7	Sept. 16	56,603	Near left bank.
2	Sand	14.0	10.8				
	Boring 45:						
1	Water	4.0	4.0	69.6	Sept. 17	58,535	Located 104 ft. from left bank.
2	Sand	14.0	10.0				
	Boring 46:						
1	Water	6.1	6.1	69.6	Sept. 17	60,172	95 ft. from left bank.
2	Sand	14.0	7.9				
	Boring 47:						
1	Water	3.5	3.5	69.5	Sept. 17	62,202	180 ft. from left bank.
2	Sand	14.0	10.5				
	Boring 48:						
1	Water	4.0	4.0	69.4	Sept. 17	64,140	Near right bank.
2	Medium fine sand	8.0	4.0				
3	Fine sand and sandy clay	14.0	6.0				
	Boring 49:						
1	Water	7.4	7.4	69.4	Sept. 17	65,586	Near midchannel.
2	Medium fine sand	14.0	6.6				
	Boring 50:						
1	Water	6.8	6.8	69.4	Sept. 18	67,256	120 ft. from left bank.
2	Sand	14.2	7.4				
	Boring 51:						
1	Water	3.5	3.5	69.4	Sept. 18	68,917	Located 114 ft. from left bank.
2	Medium fine sand	14.3	10.8				
	Boring 52:						
1	Water	6.8	6.8	69.4	Sept. 18	70,108	Near left bank.
2	Sand	11.8	5.0				
3	Fine sand and clay mixed (soft)	14.3	2.5				

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Record of the borings—Continued.

No.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Distance from foot of Ganoes canal.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.* Below.	
	Boring 53:						
1	Water	7.8	7.8	69.3	Sept. 18	71,786	125 ft. from right bank.
2	Sand	14.4	6.6				
	Boring 54:						
1	Water	5.0	5.0	69.3	Sept. 18	72,918	113 ft. from left bank.
2	Fine sand	13.5	8.5				
3	Coarse sand	14.5	1.0				
	Boring 55:						
1	Water	3.8	3.8	69.3	Sept. 18	74,420	124 ft. from left bank.
2	Coarse sand	13.3	8.5				
3	Fine sand	14.3	1.0				
	Boring 56:						
1	Water	4.0	4.0	69.2	Sept. 19	75,977	Near midchannel.
2	Coarse sand	12.0	8.0				
3	Medium coarse sand	14.0	2.0				
	Boring 57:						
1	Water	4.0	4.0	69.2	Sept. 19	77,538	Near left bank.
2	Coarse sand	12.5	8.5				
3	Sand	14.0	1.5				
	Boring 58:						
1	Water	4.0	4.0	69.2	Sept. 19	79,468	Located near left bank.
2	Sand	14.0	10.0				
	Boring 59:						
1	Water	5.0	5.0	69.0	Sept. 19	81,833	Near left bank.
2	Sand	14.0	9.0				
	Boring 60:						
1	Water	7.0	7.0	69.0	Sept. 19	84,018	37 ft. from left bank.
2	Sand	8.0	1.0				
3	Clayey sand	14.0	6.0				
	Boring 61:						
1	Water	3.8	3.8	69.0	Sept. 19	86,498	Located 78 ft. from left bank.
2	Coarse sand	8.8	5.0				
3	Clayey sand (soft)	14.0	5.2				
	Boring 62:						
1	Water	3.8	3.8	68.75	Sept. 19	89,087	140 ft. from left bank.
2	Coarse sand	6.8	3.0				
3	Clayey sand	13.0	6.2				
4	Sand	14.0	1.0				
	Boring 63:						
1	Water	11.3	11.3	68.7	Sept. 21	91,125	Near center bridge pier at Lamont.
2	Coarse sand	14.3	3.0				
	Boring 64:						
1	Water	6.5	6.5	68.7	Sept. 21	92,610	145 ft. from left bank.
2	Sand	14.0	7.5				
	Boring 65:						
1	Water	5.0	5.0	68.6	Sept. 21	95,360	60 ft. from right bank.
2	Coarse sand	14.0	9.0				
	Boring 66:						
1	Water	6.2	6.2	68.6	Sept. 21	97,853	Located near midchannel.
2	Coarse sand	7.2	1.0				
3	Fine sand	14.0	6.8				
	Boring 67:						
1	Water	4.2	4.2	68.6	Sept. 21	100,218	150 ft. from right bank.
2	Coarse sand	14.0	9.8				
	Boring 68:						
1	Water	3.0	3.0	68.6	Sept. 21	102,750	140 ft. from left bank.
2	Fine sand	14.0	11.0				
	Boring 69:						
1	Water	7.0	7.0	68.5	Sept. 22	104,698	Near right bank.
2	Sand	13.5	6.5				
	Boring 70:						
1	Water	7.5	7.5	68.5	Sept. 22	106,694	Do.
2	Coarse sand, fine gravel and shell.	13.5	6.0				
	Boring 71:						
1	Water	7.0	7.0	68.5	Sept. 22	108,843	Near lower end of dock at Eastmanville.
2	Coarse sand	10.0	3.0				
3	Sand	13.5	3.5				
	Boring 72:						
1	Water	4.0	4.0	68.4	Sept. 22	110,755	Located 96 ft. from right bank.
2	Coarse sand	12.0	8.0				
3	Sand	13.5	1.5				
	Boring 73:						
1	Water	5.0	5.0	68.4	Sept. 22	112,325	82 ft. from right bank.
2	Coarse sand	12.0	7.0				
3	Sand and clay mixed	13.0	1.0				

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Record of the borings—Continued.

No.	Material.	Depth	Thickness.	Elevation of water surface.	Date.	Distance from foot of Gauges canal.	Remarks.
		Feet.	*Feet.*	*Feet.*		*Feet.* Below.	
	Boring 74:						
1	Water	5.0	5.0	68.4	Sept. 22	114,534	Near left bank.
2	Medium coarse sand	9.0	4.0				
3	Sand	13.5	4.5				
	Boring 75:						
1	Water	6.0	6.0	68.3	Sept. 22	116,368	Mid river.
2	Medium coarse sand	9.0	3.0				
3	Sand	12.0	3.0				
4	Clay	13.5	1.5				
	Boring 76:						
1	Water	6.0	6.0	68.3	Sept. 22	117,868	170 ft. from right bank.
2	Coarse sand	13.5	7.5				
	Boring 77:						
1	Water	6.0	6.0	68.3	Sept. 22	119,848	190 ft. from left bank.
2	Sand	13.5	7.5				
	Boring 78:						
1	Water	8.0	8.0	68.5	Sept. 22	121,500	Located at mouth of Bass River.
2	Sand	13.5	5.5				
	Boring 79:						
1	Water	9.0	9.0	68.3	Sept. 23	123,846	Near left bank.
2	Sandy clay (soft)	13.0	4.0				
	Boring 80:						
1	Water	5.5	5.5	68.3	Sept. 23	126,075	250 ft. from left bank.
2	Sand	16.0	10.5				
	Boring 81:						
1	Water	7.0	7.0	68.3	Sept. 23	127,828	Near left bank.
2	Clay (hard) (gray)	13.0	6.0				
	Boring 82:						
1	Water	5.5	5.5	68.3	Sept. 23	129,075	Near right bank.
2	Coarse sand	13.0	7.5				
	Boring 83:						
1	Water	7.5	7.5	68.3	Sept. 23	131,640	Located near right bank.
2	Clay (soft) (gray)	13.0	5.5				
	Boring 84:						
1	Water	5.0	5.0	68.3	Sept. 23	134,230	Near left bank.
2	Medium coarse sand	13.0	8.0				
	Boring 85:						
1	Water	5.0	5.0	68.3	Sept. 23	137,682	52 ft. from left bank.
2	Coarse sand	10.0	5.0				
3	Sandy clay	11.5	1.5				
4	Medium coarse gravel	13.0	1.5				
	Boring 86:						
1	Water	8.0	8.0	68.3	Sept. 23	140,210	22 ft. from left bank.
2	Medium coarse sand	11.0	3.0				
3	Sandy clay	13.0	2.0				
	Boring 87:						
1	Water	8.0	8.0	68.3	Sept. 23	143,645	Near right bank.
2	Fine sand	10.0	2.0				
3	Sandy clay	13.0	3.0				
	Boring 88:						
1	Water	5.5	5.5	68.2	Sept. 23	148,285	Located near angle in row of piles at Spoonsville.
2	Fine sand	13.0	7.5				
	Boring 89:						
1	Water	5.0	5.0	68.2	Sept. 23	150,570	270 ft. from right bank.
2	Coarse sand	13.0	8.0				
	Boring 90:						
1	Water	8.0	8.0	68.2	Sept. 23	155,608	95 ft. from left bank.
2	Fine sand (hard)	13.0	5.0				
	Boring 91:						
1	Water	7.5	7.5	68.2	Sept. 23	158,820	Near left bank.
2	Fine sand	13.0	5.5				

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III.—DISCHARGE OBSERVATIONS.

Observations for determining the discharge of the river were made at two places. On July 21, 5.52 miles below Grand Rapids, or about 0.5 of a mile above Grandville, and on August 18, 16.68 miles below Grand Rapids, or about 0.6 of a mile above Lamont. The following description of the method of making observations at the section above Grandville will also describe the method followed at the lower place:

Having selected a straight and smooth section of the river as free from all obstructions as possible, two posts were set on the high bank as nearly parallel to the thread of the stream as possible and 100 feet apart. On the opposite bank two more posts were similarly set, so placed that the four posts located the angles of a rectangle. On the line across the river between the two lower posts another post was set on either side near the water's edge. A wire having been prepared with tags every 10 feet was stretched between the two last-mentioned posts and soundings carefully taken at each mark on the wire. Soundings were similary located and taken on the line of the upper posts. The wire on the upper section was so adjusted as to bring the soundings of this section directly upstream from the corresponding ones on the lower section.

The velocity of that portion of the stream lying between any two soundings on the lower section and the corresponding two on the upper section was determined by a rod float. Before dropping in a float it was so weighted as to pass down through its intended section with its lower end close to the river bed. The place for dropping in the floats was determined by stretching the wire across the river about 20 feet above the upper sounded section so as to bring the tags directly above the middle of sections determined by the corresponding down and up stream soundings. The floats were then dropped at these tags from a small boat. The time at which each float crossed the upper and lower sounded sections was taken to the nearest second.

From these observations the mean area and velocity per second of each 10-foot section of the river was determined, which multiplied together gave the discharge for that section, and the sum of these the total discharge. The total discharge divided by the total area gives the mean velocity. From the care taken to have the floats reach near the bottom, and from other considerations, it has been thought unnecessary to make any correction or deduction from the discharge as computed from the observed quantities. A temporary gauge for reference during the sounding and float observations was set and afterwards referred to a permanent bench.

The object of setting the four posts on the bank was to preserve the exact location of the gauged section in the hope that rises in the river would occur during the progress of the survey and enable new gaugings to be made at the same place at different river stages, for the purpose of comparison and more accurate determination of relative velocities and discharges due to different depths.

With the level and tape the form of the sounded sections from the water's edge to the posts at the top of the bank was determined, so that a complete section of the river between the tops of banks could be plotted, and the area and wetted perimeter for any depth could be computed. With this data such a section of the river bed midway between the sounded sections has been prepared at each of the places of observation.

The stage of the river remained almost stationary during the survey, and no opportunity offered for further gauging. The slopes, velocity, and discharges, as given in the accompanying table for other stages than that of the observation, must therefore be taken as near approximations only. The result of gauging near Grandville is given in the first line of the table.

From a comparison of the conditions of Grand River with similar conditions in other rivers where gaugings have been made, we are led to select for the coefficient of roughness in Kutter's formula a value of 0.026. Substituting this value, the observed mean velocity and the hydraulic mean radius in that formula, and solving, we get 0.000035 as the value of the slope. From the observed low water of 1889, the fall in the water surface in the 9,880 feet next above Grandville is 0.33 feet, giving a mean slope of 0.0000334. Considering the fact that the water surface at the time and place of gauging was about 0.46 feet lower than the observed low water of 1889, the two slopes differ in the right direction, and the results may be considered satisfactory. The three remaining slopes given in the table were determined from the probable river slopes at the corresponding stages, as determined from the gauge readings at Grand Rapids and Grandville.

Nine hundred and eighty cubic feet per second may, therefore, be considered the extreme low-water discharge of the river for the period of observation. Comparing this with the maximum elevation for the same period, as recorded at the Grand Rapids gauge—itself relatively as low as the low-water stage compared with the mean levels—the high-water discharge for the year becomes 12,380 cubic feet per second; and somewhere between these is the mean discharge, viz, about 5,500 cubic feet.

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The following table gives the results of the observations and computations, as derived from Kutter's formula, which is more fully elaborated on page 21:

Stages on the Grand Rapids gauge.	Corresponding stages at discharge section.	Mean depth for 300 feet width. d	Sectional area. A	Wetted perimeter. b	Hydraulic mean radius. $r=\frac{A}{b}$	Slope. i	Mean velocity. Feet per second. $v=\frac{q}{A}$	Volume, cubic feet per second. q
74.35	71.25	3.95	1,205.50	330.0	3.653	.000035	0.81419	981.5
76.00	72.92	5.62	1,765.36	345.5	5.109	.0000466	1.21866	2,151.0
79.00	76.30	9.00	2,961.91	367.5	8.059	.0000559	1.86142	5,514.0
83.00	80.22	12.92	4,365.43	392.0	11.136	.000087	2.8363	12,382.0

An examination of the tabulated gauge readings herewith will show the probable time of year and duration of the stages for which discharges have been computed.

Statement of the mean, highest and lowest monthly elevations of river surface observed at the Grand Rapids, Grandville, and Lamont gauges, and of the lake surface at Grand Haven.

Months.	Means.				Highest observed.				Lowest observed.			
	Grand Rapids.	Grandville.	Lamont.	Grand Haven.	Grand Rapids.	Grandville.	Lamont.	Grand Haven.	Grand Rapids.	Grandville.	Lamont.	Grand Haven.
1891.												
January	76.84	73.61	70.49	67.98	78.42	75.06	71.05	69.10	75.87	72.76	69.95	67.40
February	77.63	74.58	71.40	67.85	82.32	79.36	75.35	68.55	75.72	72.96	70.05	67.00
March	80.59	78.16	74.03	67.89	85.32	82.76	77.55	68.39	77.67	74.86	71.45	67.15
April	80.13	77.20	73.33	68.21	83.17	80.16	75.55	68.85	76.97	73.86	70.85	67.60
May	75.61	72.30	69.60	68.33	76.87	73.76	70.85	68.85	74.92	71.46	69.05	67.78
June	75.13	71.67	69.34	68.43	75.67	72.46	69.75	69.40	74.42	71.06	69.05	67.99
July	74.45	71.19	69.05	68.36	75.17	71.86	69.45	68.95	73.84	70.76	68.75	67.77
August	74.01	70.80	68.77	68.27	75.02	71.76	69.55	68.70	73.60	70.46	68.55	67.96
September	74.28	71.19	68.94	68.03	74.82	71.76	69.45	68.70	73.80	70.41	68.45	67.39

SUMMARY OF FIELD OPERATIONS.

Instrument stations	705
Length of transit lines run in miles	97
Stadia pointings	18,500
Length of levels run in miles	9
Posts set	103
Discharge observations made	2
Square miles of topography taken	14
Borings made	92
Borings located	92

MAPS.

Upon completing the field work, the reduction and plotting of the field notes was at once begun and the computation of ground elevations was completed September 30, 1891. These elevations have been plotted on two continuous rolls of paper of 10 yards each to a scale of 1 inch to 200 feet. Contour lines are being drawn on the maps 2 feet apart except on a few steep slopes where they are 10 feet apart. The even 10-foot contours are in red; all others are in black. Topographical signs are omitted wherever words will serve to describe the character of the surface. The contours are yet to be drawn on a portion of these maps.

A tracing has been made from the map of the survey of 1889 of that portion of the river lying between the lower end of the present topographical survey and Grand Haven, on which contours have been drawn as accurately as the few elevations would permit, but at best these contours must be regarded as approximate only.

The soundings of the survey of 1889 have been reduced to low water of November of that year and plotted on the present map and the tracing above noted. Lines of equal depth 2 feet apart vertically are being drawn on these maps.

A reduced map of the river from Grand Rapids to Grand Haven on a scale of 1 inch to 1,600 feet has been prepared.

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PROFILE.

A profile of the river from Grand Rapids to Grand Haven has been prepared showing the low-water surface of November, 1889, which is nearly as low as that of 1891, the surface of the water at the time the soundings were taken, the probable water surface for each 1 foot rise on the Grand Rapids gauge from a 75 to an 83 foot stage, the location and depth of borings, and a mean profile of the river-bed averaged for a width of 100 feet.

The line along which this profile is made is shown on the maps, and, approximating to the present channel, is the line along which it is thought the proposed improvement should be made. A reduced profile of the entire river has also been made. Lines showing the bottom of proposed dredging are also shown on these profiles.

GAUGE READINGS.

Gauge readings were taken at four places on the river from December 22, 1890, to October 13, 1891, namely, at Grand Rapids, Grandville, Lamont, and Grand Haven. These readings have been plotted on profile paper for convenience of comparison.

*List of maps and profiles of Grand River, below Grand Rapids, submitted herewith.**

1. A map of upper 12 miles of river.
2. A map of middle 12 miles of river.
3. A tracing of lower 15 miles of river.
4. A tracing of reduced map and profile of river.
5. A profile of river.
6. Gauge reading.
7. Sections of borings.

The following table shows the low-water (1889) slopes, total fall, and fall in inches per mile of different portions of the river. It will be seen from it that the fall from Grand Rapids to Grandville, a distance of 6 miles, is 2.85 feet, or 5.73 inches per mile; that from Grandville to Lamont, a distance of 11.5 miles, it is 2.92 feet, or 3.05 inches per mile; and that from Lamont to Grand Haven, a distance of 21.64 miles, the fall is 0.43 foot, or 0.24 inch per mile; also that from Grand Haven to the mouth of Sand Creek, a distance of 27.26 miles, the fall is only 1.04 feet, or 0.46 inch per mile, leaving 5.16 feet fall in the upper 12 miles. Any contemplated improvement must therefore be principally concerned with these upper 12 miles.

Low water (1889) slopes and total fall.

Place.	Distance from canal.	Elevation.	Place.	Distance from canal.	Elevation.	Difference of distance.	Difference of elevation.	Slope.	Fall per mile.
									Ins.
Ganoes Canal	0	74.47	B. M. 2	4,320	74.09	4,320	.38	.0000877	5.56
B. M. 2	4,320	74.09	B. M. 3	8,260	73.64	3,940	.45	.0001142	7.24
B. M. 3	8,260	73.64	B. M. 4	13,442	72.42	5,182	1.22	.000235	14.89
B. M. 4	13,442	72.42	B. M. 5	16,956	72.39	3,514	.03	.0000085	.54
B. M. 5	16,956	72.39	B. M. 6	21,624	71.95	4,668	.44	.000094	5.96
B. M. 6	21,624	71.95	B. M. 8	31,504	71.62	9,880	.33	.000033	2.09
B. M. 8	31,504	71.62	B. M. 9	32,695	71.57	1,191	.05	.000042	2.66
B. M. 9	32,695	71.57	B. M. 11	38,453	71.01	5,768	.56	.000097	6.15
B. M. 11	38,453	71.01	B. M. 12	43,735	70.14	5,282	.87	.0001647	10.44
B. M. 12	43,735	70.14	B. M. 13	46,805	70.04	3,070	.10	.0000325	2.06
B. M. 13	46,805	70.04	B. M. 14	50,295	69.95	3,490	.09	.000026	1.65
B. M. 14	50,295	69.95	B. M. T	55,636	69.70	5,341	.25	.0000468	2.97
B. M. T	55,636	69.70	B. M. J	62,570	69.31	6,934	.39	.0000562	3.56
B. M. J	62,570	69.31	B. M. 15	77,530	69.18	14,960	.13	.0000087	.55
B. M. 15	77,530	69.18	B. M. I	84,961	69.00	7,431	.18	.0000242	1.53
B. M. I	84,961	69.00	B. M. S	88,165	68.84	3,204	.16	.0000499	3.16
B. M. S	88,165	68.84	B. M. 19	92,235	68.70	4,070	.14	.0000344	2.17
B. M. 19	92,235	68.70	B. M. II	97,386	68.58	5,151	.12	.0000233	1.48
B. M. II	97,386	68.58	B. M. III	105,105	68.50	7,719	.08	.00001036	.66
B. M. III	105,105	68.50	B. M. IV	110,382	68.44	5,277	.06	.00001137	.72
B. M. IV	110,382	68.44	B. M. V	119,297	68.36	8,915	.08	.00000819	.52
B. M. V	119,297	68.36	B. M. VI	126,080	68.34	6,783	.02	.00000295	.19
B. M. VI	126,080	68.34	B. M. VII	135,305	68.29	9,225	.05	.00000542	.34
Grand Haven	206,500	68.27	B. M. 19 Lamont (B. M. J.).	92,235	68.70	114,265	.43	.000003763	.24
Do	206,500	68.27	Sand Creek	62,570	69.31	143,930	1.04	.000007225	.46
Lamont B. M. 19	92,235	68.70	do	62,570	69.31	29,665	.39	.000013147	.83
Do	92,235	68.70	B. M. 8, Grandville	31,504	71.62	60,731	2.92	.0000480808	3.05
Sand Creek B. M. J.	62,570	69.31	do	31,504	71.62	31,066	2.31	.000074358	4.71
Grandville	31,504	71.62	Foot of Ganoes Canal.	0	74.47	31,504	2.85	.0000904647	5.73

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*Not printed.

For the purpose of showing the relation between quantity of discharge, slopen, and section of channel, the following table has been prepared by the aid of the Ganguillet and Kutter formula:

$$v=\left(\frac{a+\frac{l}{n}+\frac{m}{i}}{1+\left(a+\frac{m}{i}\right)\frac{n}{\sqrt{r}}}\right)\sqrt{ri}$$

in which $a=41.66$, $l=1.81132$, and $m=0.0028075$.
v=mean velocity, r=the hydraulic mean radius.
i=sine of slope and n=coefficient of roughness of perimeter.
In the table n is taken = .026.
The form of a section of the channel is assumed to be trapezoidal.
z=width of base.
θ=angle of inclination of sides to the horizon.
d=depth.
A=area.
b=wetted perimeter.
Hence,

$$A=dz+\frac{d^2}{\tan\theta}=\frac{dz\tan\theta+d^2}{\tan\theta}$$

and

$$b=z+\frac{2d\sec\theta}{\tan\theta}=\frac{\tan\theta\, z+2d\sqrt{1+\tan^2\theta}}{\tan\theta}$$

Table to ascertain dimensions of channel to be filled.

z	$\tan\theta$	d	A	b	r	n	i	Fall per mile.	v	q
								Inches.		
153	½	6	918	179.83	5.1049	.026	.000035	2.2176	1.06612	980.0
78	½	8	752	113.776	6.6090	.026	.000035	2.2176	1.30416	980.0
100	½	8	992	150.600	6.5870	.026	.000019	1.20384	0.9929	980.0
90	½	8	848	125.777	6.7405	.026	.000026	1.64736	1.1615	980.0
49	½	10	690	93.720	7.3626	.026	.000035	2.2176	1.4183	980.0
90	½	10	1100	134.72	8.1650	.026	.000011	0.69696	0.88819	980.0
100	½	10	1300	163.245	7.963	.026	.000007	0.44352	0.75346	980.0
90	½	10	1100	134.72	8.165	.026	.0006	3.8016	1.9360	2150.0
100	½	10	1300	163.245	7.963	.026	.000044	2.78784	1.6539	2150.0
102	½	10	1220	146.7	8.3163	.026	.0000466	2.952576	1.7607	2150.0

The quantity of discharge, q, taken in the table in all except the last three cases, is seen to be the observed low-water discharge at the 1891 ganging above Grandville, and in the last three cases q is the discharge at the same place for a 76-foot stage at Grand Rapids, which is 1.53 feet above the low-water stage.

For example: Assuming $i=.000035=2.2176$ inches per mile, which is the existing mean slope for nearly 2 miles above Grandville, a 6-foot channel with side slope of 2 to 1 could have a base of 153 feet; if the depth be increased to 8 feet with same side slopes, the width on the bottom is reduced to 78 feet; and for a 10-foot channel the corresponding width is 49 feet. Again, for $i=.000007=0.44352$ inches per mile, which will be seen from a preceding table to be nearly the existing slope of the river for the lower 27.26 miles, and $q=980$, a 10-foot channel may be 100 feet wide on the bottom and have a side slope of 3 to 1.

PROJECTS FOR OPEN CHANNEL.

In accordance with your instructions, an open 8-foot channel by dredging and two plans for obtaining a 10-foot channel of navigable width have been considered, one by dredging alone, and the other by dredging supplemented by a dam and a lock. Below the proposed dam and lock these two plans are identical, the required depth to be obtained by dredging and maintained by wing dams and training dikes at crossings and such other places as experience may prove necessary. Estimates have also been made for obtaining an 8-foot channel by dredging. The location in the river of the line along which estimates are made is indicated on the maps. After passing

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the two drawbridges at Grand Haven, it is proposed to pass up the left channel to the middle channel, and thence up the middle channel to the main river channel. The length of this middle channel is about 4,400 feet. It already has a maximum depth of more than 10 feet throughout its whole length, and a mean depth of 10 feet for 100 feet in width in the lower 2,700 feet, and a mean depth of 8 feet for the same width in the upper 1,700 feet. The upper end of this channel should be widened and straightened. The expense would be small and is fully covered by the estimates. After leaving the middle channel the line follows approximately the existing one.

The "Ottawa Boom" has been removed, and all logging interests in the river are now at an end. With the exception of the few hundred feet at the head of the middle channel mentioned above, a more than 10-foot channel already exists for 6¼ miles above Grand Haven. Above this point as far as the mouth of Bass River, or 9½ miles farther, a 7 to 8 foot channel exists. Above Bass River the depth of channel varies, but excepting at the shoalings and bars given in the following table a 4-foot channel exists to Grand Rapids:

Tabular statement of the location of shoalings and bars with less than 4 feet of water.

Number.	Distances below foot of Ganoes Canal, Grand Rapids.		Length.	Depth at crossing.	Location.
	Beginning.	End.			
	Feet.	*Feet.*	*Feet.*	*Feet.*	
1	0	270	270	3.0	
2	800	1,200	400	3.6	
3	2,900	3,400	500	3.0	
4	4,300	4,750	450	3.9	
5	5,550	5,950	400	3.5	Mouth of Plaster Creek.
6	8,200	9,600	1,400	3.0	Opposite Lower Plaster Mill.
7	13,500	15,100	1,600	2.5	Just below Lake Shore and Michigan Southern Railroad Bridge.
8	16,500	17,350	850	2.7	
9	17,800	21,300	3,500	2.0	
10	24,750	25,000	250	3.8	
11	27,600	28,050	450	2.9	Clam Shell Bar.
12	36,100	36,600	500	3.8	
13	39,350	40,000	650	3.6	At Weatherwax's.
14	41,400	43,200	1,800	3.0	At Boynton's.
15	49,000	50,100	1,100	3.0	
16	56,400	56,900	500	3.8	At Haire's.
17	74,600	77,100	2,500	2.6	At Bridge Street Ferry.
18	77,450	77,700	250	3.6	
19	79,500	80,700	1,200	3.2	
20	85,050	89,700	4,650	2.3	Just above Lamont.
21	95,700	96,500	800	2.7	Do.
22	100,400	103,000	2,600	2.8	
23	113,900	114,400	500	3.0	Just below Eastmanville.
Total			27,120		

From Grand Haven to Grandville, about 33 miles, the slope assumed for a 10-foot dredged channel is 0.000007, or 0.44352 inch per mile, or about the mean existing slope of the river in the lower 27¼ miles. From Grandville to Grand Rapids the slope is taken at 0.000011, or 0.69696 inch per mile. For the low-water discharge of the river, as obtained at the gauging above Grandville, the former gives a channel 100 feet wide on the bottom and side slopes of 3 to 1 and the latter a channel 90 feet wide on the bottom and side slopes of 2 to 1. From the nature of the material, as determined by the borings, it is thought that these side slopes will in most places be quite permanent. The 90 and 100 foot width of bottom and corresponding top width of 130 and 160 feet are thought to be sufficient. To dredge this channel will require the removal of 4,000,000 cubic yards, which at 10 cents per cubic yard will cost $400,000.

Such a dredged channel would lower the water at Grandville about 2.1 feet, and at Grand Rapids about 4.6 feet at low-water stages, this effect decreasing with higher stages of the stream.

At Grand Rapids a basin large enough to accommodate boats in passing and turning can be obtained by the excavation of about 70,000 cubic yards of material, which at 20 cents per cubic yard would cost $14,000.

In the plan with lock and dam a similar basin can be obtained by the excavation of 40,000 cubic yards at a cost of $8,000.

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PROJECT FOR 10-FOOT CHANNEL BY DREDGING, WITH LOCK AND DAM.

The site selected for a lock and dam is in the vicinity of boring 37, about 42,000 feet, or nearly 8 miles, below Grand Rapids. At and above this place the river valley is of medium width, and the immediate banks are about 11 feet above low-water surface. The width of the river at low water is about 460 feet.

From the fact that the sewer outlet of West Grand Rapids empties into the river about a mile below the city, and that the fall in this sewer is slight, it is not considered practicable to raise the water at this point above its present low-water stage. Any considerable rise would materially interfere with the city drainage and would probably render pumping necessary. The height of the crest of the dam is therefore fixed at an elevation of 74 feet. Below the site of the proposed dam the dredged 10-foot channel is to remain the same in dimensions and slope as in the plan by dredging alone. The elevation of its bottom, therefore, at the dam is 59.4 feet. Above the dam the bottom of the dredged channel is placed at an elevation of 64 feet and made level from the dam to Grand Rapids. The miter sill of the upper gates has an elevation of 63 feet. The lift of the lock will, therefore, be 4.6 feet. The dredged channel above the lock is given a base of 90 feet, with side slopes of 2 to 1. The low-water surface at Grand Rapids will be practically unchanged, and at the lock raised 3.6 feet.

Very little, if any, actual flooding of adjacent lands would result from this elevation of water surface, but the effect would be to make several swamps, now comparatively dry during the summer months, continuously wet and, at moderate rises, to flood them. This might be obviated in some degree by constructing suitably large waste ways in the dam, but no doubt, as in similar cases, the construction of a dam would cause some property-owners above it to seek for land damages. Computations show that at high water the dam would be drowned out, so that practically no effect would be produced on high-water slopes and heights.

The amount of excavation required for a 10-foot channel is 2,342,830 cubic yards below and 727,170 cubic yards above the dam, or a total of 3,070,000 cubic yards, which, at 10 cents per yard, will cost $307,000.

Lock.—The lock is placed in the bed of the stream near the left bank. Estimates have been made for a lock chamber 50 by 300 feet, and lock walls 400 feet in length. The top of lock walls is placed 4 feet above the crest of the dam and would be submerged at high water. The river wall is estimated with 8-foot base and 5-foot coping except for 110 feet opposite gate recesses, where no batter is given to the wall. The land wall is estimated with 7-foot base and 4-foot coping except for 40 feet opposite gate recesses, where no batter is given to the wall. The foundation is of piles with grillage. The estimate includes concrete around the piles and between the grillage timbers in the foundation. The walls are faced with cut stone backed with rubble, and, in the case of the river wall, filled with concrete.

Estimated cost of lock.

Material.	Unit.	Price.	Quantity.	Cost.	Total.
Cut stone	Cubic yard	$15.00	1,490	$22,350	
Coursed rubble	do	8.00	1,210	9,680	
Concrete	do	4.50	2,252	10,134	
					$42,164
Piles	One	3.00	1,715	5,145	
Timber	M. B. M	30.00	299,800	8,994	
					14,139
Excavation	Cubic yard	.25	14,590	3,647.50	
Filling between lock wall and bank	do	.25	8,150	2,037.50	
					5,685
Paving between lock wall and bank	do	3.00	740	2,220	2,220
Four valves and fixtures for filling and emptying					800
Four gates, with anchorages and fixtures					4,000
200 feet of cribs (with stone filling) on piles, above lock walls, and 100 below					7,000
Coffer dam					3,000
Lock-keeper's house					1,800
Site					1,000
Total					$81,808

Dam.—The estimate is for a fixed dam 400 feet long placed opposite the hollow quoins of the lower gates. At the end of the dam on the right bank the estimate provides for grading and paving the bank for 150 by 50 feet.

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The core of the proposed dam estimated for is formed of two rows of piles and sheet piling about four feet apart, between which the earth is excavated and the space filled in with concrete. Below the core two rows of piles are placed, one at the foot of the downstream slope of the over fall and the other at the lower edge of the apron. Between the piles of this lower row and a similar row above the core wall sheet piling is driven. Estimates are made for gravel and stone filling with a suitable covering of planking and rock filling below the apron.

Estimated cost of dam.

Material.	Unit.	Price.	Quantity.	Cost.	Total.
Piles	One	$6.25	160	$1,000.00	
Do	do	4.00	240	960.00	
Piles (sheet)	M. B. M.	40.00	92,160	3,686.40	
Timber	do	40.00	62,400	2,496.00	
Planking	do	60.00	80,000	4,800.00	
Concrete	Cubic yard	4.50	680	3,060.00	
Gravel and stone filling	do	.75	1,616	1,212.00	
Rock filling below dam	do	1.75	1,112	1,946.00	
					$19,160.40
Earth excavation	do	.50	364	182.00	182.00
Grading and paving bank at end of dam	Cubic yard	3.00	278	834.00	834.00
Total					20,176.40

A somewhat similar dam, but with only one central row of piles and sheet piling, and without the concrete core, will cost $15,200.

ESTIMATE FOR 8-FOOT CHANNEL BY DREDGING.

Estimates are made for an 8-foot channel by dredging. From Grand Haven to the mouth of Sand Creek (27.26 miles) the slope taken is .000007 (0.44352 inches per mile); thence to Grandville (5.88 miles) it is .000019 (1.20384 inches per mile). One hundred feet at the base and side slopes of 3 to 1 is the section assumed for the above distances. From Grandville to Grand Rapids the slope is .000026 (1.64736 inches per mile), and the section has a 90-foot base, with side slopes of 2 to 1. The surface of the water at Grand Rapids would be lowered about 1.8 feet. The removal of 2,260,000 cubic yards of material would be required, costing, at 10 cents per yard, $226,000. A winding basin at the upper end would cost $8,000.

WING DAMS AND TRAINING DIKES.

In determining the inclination and the dimension of the section of a channel that will discharge the low-water flow of the river, the assumption of course is that the entire quantity of water discharges through that section. A dredged channel of the form and size selected would not be more than 130 to 160 feet wide at the surface. The present width of the river varies from about 350 to about 600 feet at low water. In order therefore to confine the flow to a sufficiently narrow channel and at the same time to prevent the dredged material from finding its way back into it, wing dams or training dikes, or both, may be required at various places to maintain a channel of requisite depth. Such works would especially be needed at crossings and at a few wide and straight portions of river where shoaling occurs. In the whole length of the river there are about twenty crossings. The lower seven of these, being where only 2 to 3 feet of dredging will be required to open a 10-foot channel and in a part of the river where there is little current even at high water, will probably require no particular works, as it will be less expensive and more satisfactory to remove by dredging from time to time any slight shoaling that may occur at these places.

Again, in the upper 5 miles of river, where five crossings occur and where the project for an open 10-foot channel contemplates the lowering of the bed of the stream at low stage from 2 to 4 feet, and where, too, the material to be dredged is composed largely of clay, coarse gravel, cobblestone, and bowlders, it is thought that a proper disposition of the dredgings, supplemented by the encouragement of a willow and other growth on the dredge dumps and portions of the river bed which for low stages will be out of water, may secure a practically permanent channel without the aid of wing dams or dikes. At and in the vicinity of the remaining eight crossings, which are distributed over a distance of about 18 miles of river and where the material for a large fraction of this distance is largely sand, works more or less

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extensive will be required to maintain a channel. However, the placing of any such works in the bed of the stream, where they must prove more or less obstructive to ice, etc., and must require an annual expenditure for maintenance, should not be done until other and less objectionable works shall have been proven insufficient or until experience has shown such works absolutely necessary and more economical than other means that could be used to obtain the same end.

As a preliminary estimate it will be assumed that the construction of the equivalent of 1 mile of pile and sheet piling in the form of wing dams or training dikes, or both, will be required on an average at each of the eight crossings. Such works will cost $2.50 per running foot in place, or about $13,000 per crossing, making a total of $104,000 for the eight crossings. For the remaining 10 of the 18 miles now under consideration, $6,500 per mile or a total of $65,000 may be sufficient to maintain the desired depth, making the total estimated first cost for wing dams and training dikes $169,000. Rather than to expend a much larger sum than this or even this amount in contracting the low water way, it might prove better economy to deepen the dredging to a still greater degree than now estimated for and to rely on annual dredging to maintain the channel. But not until a channel has been opened, and the action of the river under its new conditions been observed, will it be possible to determine these points.

No change in the estimates as above given for the dredged 10-foot channel is made in the case of the 10-foot channel by dredging with lock and dam or in the case of the 8-foot channel by dredging.

Summary of first cost for 10-foot dredged channel.

Dredging	$400,000
Wing dams and training dikes	169,000
Enlargement of channel to form basin at Grand Rapids	14,000
	583,000
Contingencies, 15 per cent	87,500
Total	670,500

Summary of first cost, 10-foot channel with lock and dam.

Dredging	$307,000
Wing dams and training dikes	169,000
Dam	20,175
Lock	81,808
Enlargement of channel to form basin at Grand Rapids	8,000
	585,983
Contingencies, 15 per cent	87,897
Total	673,880

Summary of cost for an 8-foot dredged channel.

Dredging	$226,000
Wing dams and training dikes	169,000
Enlargement of channel to form basin at Grand Rapids	8,000
	403,000
Contingencies, 15 per cent	60,450
Total	463,450

STABILITY OF THE RIVER.

The course of the river is comparatively straight and most of the bends are made with easy curves. The banks are firm and nowhere show caving or change of any kind. In the bed of the stream little or no movement of material has been observed at low water. The water too is clear and free from material carried in suspension. The dam at Grand Rapids provides a settling basin for all such material.

There exists at the present time in the bed of the stream, not far removed from the channel, dredge dumps placed there six or seven years ago. The fact that these have remained, without any effort having been made to confine the material behind

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training dikes or to contract the channel width, and that some of them are from 2 to 4 feet above low water, and have young willows growing upon them, strongly indicates that a permanent channel when once formed can be maintained with small expense.

A comparison of soundings taken in 1884 previous to dredging, and again in 1889, some years after dredging had been done, indicate that, except at crossings, the filling in of the excavated channel has not been great.

The estimated first cost of improvement with lock and dam being somewhat greater than that of the open channel, the inconvenience to navigation of a lock, added to the annual cost of maintaining and operating it, make the open channel preferable as well as more economical. There is also the following consideration in favor of the open 10-foot channel: The lowering of the river bed 4.5 feet at Grand Rapids, as this plan contemplates, would make a water power there which might be utilized in increasing the already large manufacturing interests of that city. Taking the minimum low-water discharge of the river, viz, 980 cubic feet per second=61,152 pounds per second and 4.5 feet head, we have a theoretical horse power $=\frac{61,152\times4.5}{550}=500.3$, which with an efficiency of 80 per cent. gives 400.2 as the actual horse power attainable.

Allowing 5 pounds of coal to the horse power per hour, if this power be used 24 hours a day for three hundred and ten days in the year, the quantity of coal to give the same power will be 7,440 tons, worth, at $2.25 per ton, $16,740, yearly. If the power is used only 10 hours a day for 310 days in the year, it will be equivalent to 3,100 tons of coal, worth $6,975 yearly. For a large part of the year the available power would be considerably larger, but even this amount, if capitalized at 5 per cent, would justify the expenditure of $334,800, or $139,500 for the open channel in excess of the cost of a channel with lock and dam.

The following gentlemen assisted in the field work: E. C. Dunbar, assistant engineer; Robert L. Sackett, E. L. Allor, F. A. Sager, H. Baldwin, and H. B. Beecher. L. W. Goddard, assistant engineer, and R. Stierle assisted in part of the office work.

Very respectfully, your obedient servant,

FRED MORLEY,
Assistant Engineer.

Col. WILLIAM LUDLOW.
Corps of Engineers, U. S. A.

Statement of the jobbing business of Grand Rapids for 1891.

Nature of business.	No.	Capital employed.	Amount of business of 1891.	No. of employés.
Boots, shoes, and rubbers	4	$200,000	$325,000	56
Books and stationery	1	100,000	300,000	49
Clothing	2	150,000	275,000	168
Commission produce	7	118,000	1,000,000	174
Crockery	2	165,000	345,000	56
Dry goods	4	800,000	1,400,000	295
Drugs	2	165,000	500,000	27
Groceries	6	900,000	5,000,000	143
Hardware	2	500,000	908,000	117
Hats, caps, and furs	2	25,000	60,000	12
Hides, pelts, and wool	4	525,000	800,000	22
Jewelry	1	10,000	25,000	5
Lime and cement	4	50,000	200,000	16
Liquor	4	200,000	500,000	31
Notions	1	35,000	150,000	6
Packing	2	73,000	375,000	41
Paper	2	92,000	350,000	23
Paints and oils, etc	3	200,000	500,000	31
Photograph supplies	1	10,000	25,000	6
Rags, and peddlers' supplies	3	10,000	50,000	24
Saddlery hardware	2	100,000	350,000	29
Spices	2	25,000	150,000	23
Yeast	3	10,000	25,000	11
Total	67	4,463,000	13,613,000	1,365

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Summary of traffic done by the six railroads and one steamboat line for 1891.

Freight—		
Forwarded	tons..	354,206
Received	do...	882,743
Passengers—		
Outward		523,030
Inward		482,973
Freight trains daily—		
In		37
Out		36
Passenger trains daily—		
In		40
Out		40

Comparative statement of bank clearings for six years.

1886	$21,420,206.11
1887	27,959,193.65
1888	30,932,342.29
1889	34,068,269.71
1890	38,286,226.56
1891	44,636,146.38

H. D. C. VAN ASMUS,
Secretary Board of Trade, Grand Rapids, Mich.

Statement of the manufacturing industries of Grand Rapids for 1891.

Nature of business.	No.	Capital employed.	Amount of business of 1891.	Number of employés.
Agricultural implements	1	$80,000	$180,000	50
Asbestine stone	4	7,500	100,000	46
Awnings, etc	1	10,000	30,000	10
Baking powder, spices, etc	2	45,000	145,000	25
Band instruments	1	2,800	11,700	9
Barrel and keg	12	542,000	745,000	442
Ball bats, etc	1	20,000	90,000	58
Baskets	1	2,500	7,500	18
Belting	2	95,000	145,000	60
Blank books	7	35,000	98,500	52
Bicycle	1	20,000	50,000	60
Boat	2	3,500	20,000	12
Boiler	2	9,200	75,000	26
Boot and shoe	2	125,000	300,000	180
Boot and shoe upper	1	5,000	13,000	8
Bottling	7	43,500	151,000	37
Brass foundries	2	78,000	130,000	177
Breweries	8	450,000	600,000	145
Brick and tile	6	182,000	975,000	131
Broom	6	7,100	67,500	40
Brush	3	125,000	142,500	121
Burial caskets	2	87,000	178,000	82
Boxes:				
Cigar	1	3,500	10,000	8
Paper	1	12,000	25,000	27
Wood	4	62,500	240,000	85
Carding mill	1	1,000	2,500	4
Carpet sweeper	2	400,000	688,000	362
Weaving (carpet)	18	5,000	33,000	31
Carriage and wagon	23	670,000	1,147,500	472
Carriage body	1	15,000	25,000	15
Carver's tools	1	2,000	5,000	3
Car shop	1	200,000	390,000	343
Children's wagons, etc	1	19,000	40,000	46
Cider and vinegar	2	5,000	32,000	16
Cigar	43	251,000	780,000	218
Closet seat and tank	1	10,000	22,000	20
Clothing	26	250,000	845,000	382
Clothes wringer	1	15,000	50,000	10
Coffee extract	2	2,300	5,000	5
Confections	3	125,000	500,000	157
Coopers	10	24,000	262,000	34
Cornice, metallic	4	21,500	86,300	64
Corset	1	7,000	12,500	12
Cutlery	1	1,000	5,000	4
Crackers, etc	2	167,000	325,000	63
Door plate	1	1,000	1,500	2

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Statement of the manufacturing industries of Grand Rapids for 1891—Continued.

Nature of business.	No.	Capital employed.	Amount of business of 1891.	Number of employés.
Edge tool	1	$9,000	$11,000	13
Electrotype	1	8,000	35,000	7
Electric light	2	350,000	385,000	54
Embalming fluid	2	25,000	50,000	7
Engraving	4	13,000	76,000	27
Excelsior	3	30,000	52,000	35
File	1	4,000	12,300	6
Fire grate	1	65,000	215,000	60
Fire ladder and truck	1	10,000	25,000	15
Fishing rod	1	6,000	25,000	10
Flavoring extract	2	55,000	75,000	15
Fly paper	1	25,000	75,000	10
Flouring and feed mill	10	950,000	2,200,000	152
Furniture	46	6,160,300	10,010,000	6,613
Furniture clamp	1	2,500	8,500	4
Furniture, wood trimmings	8	176,000	238,500	106
Galvanized iron, etc	25	72,400	357,750	152
Gas	1	600,000	175,000	41
Glove	2	2,000	4,800	7
Glue	1	25,000	25,000	10
Hand screw	1	10,000	25,000	20
Harness	14	102,150	342,150	116
Hat	1	1,000	6,000	4
Iron, cast, ornament	1	2,000	5,000	4
Lithograph	1	10,000	10,000	14
Machine	16	778,000	1,116,200	567
Marble and granite	8	56,100	141,000	91
Middling purifier	1	25,000	65,000	13
Matches, paper	1	3,000	.....	5
Patent medicine	7	34,500	172,200	29
Piano case	1	15,000	25,000	25
Pickles	2	2,500	6,200	27
Planing mill, sash, door, etc	27	2,867,000	4,950,000	1,554
Plaster mill	5	450,000	215,000	141
Portable house	1	5,000	21,000	7
Potash	1	2,000	8,000	4
Potteries	2	8,000	27,000	23
Pump	1	5,000	10,000	7
Saw	1	5,000	18,000	12
Saw swage	1	10,000	15,000	9
Screen doors and windows	3	2,500	24,500	16
Sheet music	1	1,500	2,700	4
Shirt	5	25,400	233,000	127
Shoe button fastener	1	25,000	25,000	15
Show case	2	3,000	14,500	17
Staves and headings	2	70,500	292,000	76
Stamp, stencil	3	12,200	22,000	9
Stone, cut	5	35,000	146,000	40
Tanneries	2	345,000	470,000	102
Trunk	2	18,400	53,000	22
Truss	1	2,000	6,500	2
Umbrella	1	6,000	18,000	9
Veneer	1	100,000	200,000	100
Wall coating compound	1	225,000	575,000	174
Well and cistern brick	2	2,300	11,600	12
Wheelbarrow	1	17,000	51,000	32
Willow and rattan (not furniture)	1	7,000	21,000	15
Window shade	1	200	1,000	2
Wire nail	1	15,000	40,000	12
Wire goods	2	4,200	13,500	9
Wood carving	8	3,000	32,000	16
Wooden shoes	3	3,450	27,000	17
Wooden ware (not enumerated)	17	78,000	172,000	61
Wool puller	1	10,000	15,000	12
Zinc etching	1	2,000	5,000	4
	498	18,228,000	33,555,900	14,900
Establishments included by the U. S. Census Bureau in 1890, in the schedule of manufactures, but which are local in their nature, will add to this table with a corresponding increase	465	347,000	1,642,650	2,898
Total	963	18,575,000	35,198,550	17,888

H. D. C. VAN ASMUS,
Secretary Board of Trade, Grand Rapids, Mich.

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APPENDIX L L.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS IN EASTERN MICHIGAN.

REPORT OF COLONEL O. M. POE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. St. Marys River, Michigan.
2. Operating and care of St. Marys Falls Canal, Michigan.
3. Dry dock at St. Marys Falls Canal, Michigan.
4. Hay Lake Channel, St. Marys River, Michigan.
5. Harbor at Cheboygan, Michigan.
6. Harbor at Thunder Bay, Michigan.
7. Thunder Bay River, Michigan.
8. Harbor at Au Sable, Michigan.
9. Saginaw River, Michigan.
10. Harbor of refuge at Sand Beach, Lake Huron, Michigan.
11. Black River at Port Huron, Michigan.
12. Mouth of Black River, Michigan.
13. St. Clair Flats Canal, Michigan.
14. Operating and care of St. Clair Flats Canal, Michigan.
15. Clinton River, Michigan.
16. Grosse Pointe Channel, Michigan.
17. Rouge River, Michigan.
18. Detroit River, Michigan.
19. Removing sunken vessels or craft obstructing or endangering navigation.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 16, 1892.

GENERAL: I have the honor to transmit herewith the annual reports relating to the works of river and harbor improvements under my charge, for the fiscal year ending June 30, 1892.

* * * * * * *

I am, sir, very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers,
Bvt. Brig. Gen., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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L L 1.

IMPROVEMENT OF ST. MARYS RIVER, MICHIGAN.

The project for obtaining a navigable channel of 16 feet depth between Lakes Superior and Huron had been barely completed when the demands of commerce so enormously increased that the work of obtaining a depth of 20 feet throughout was undertaken, with the full sanction of both legislative and executive authority.

A necessary part of the project is the construction of a new lock upon the site of the old State locks, to have a length of 800 feet between gates, a width of 100 feet throughout, a depth of 21 feet on the miter sills, and a single lift approximating 18 feet. The canal is to be deepened to correspond. The estimated cost of this enlargement of the canal system is $4,738,865, for the details of which see page 2220 *et seq.* of the Annual Report of the Chief of Engineers for 1887.

Prior to June 30, 1890, a total of $1,250,000 had been appropriated for the work. The river and harbor act of September 19, 1890, appropriated an additional $900,000 for continuing the improvement with the provision "that such contracts as may be desirable may be entered into by the Secretary of War for materials and labor for the entire structure and approaches, or any part of the same, to be paid for as appriations may from time to time be made by law;" and the sundry civil act of March 3, 1891, appropriated $600,000 for continuing the improvement during the fiscal year ending June 30, 1892. The total amount appropriated up to date, therefore, is $2,750,000, with authoritiy to contract for all or any part of the work.

For the time being the work is confined to the improvement of St. Marys Falls Canal and its approaches. On June 30, 1891, its condition was as follows, viz: The cofferdam surrounding the site of the 800-foot lock was in good condition; the excavation of the lock pit had been carried below grade, except a small area at the eastern incline, and the contractors were engaged in removing a considerable amount of loose and broken stone below grade; and a considerable amount of filling yet remained to be done behind Fort Brady Pier.

The contractors for the masonry of the lock walls had a considerable portion of their plant in readiness for use; had begun quarrying face stone at Kelly Island, Lake Erie, and backing stone at Drummond Island, Michigan; were receiving cement and had begun laying concrete in the lock foundations, but no estimate had yet been made for payment therefor.

The following contracts were in force during the year, viz:

Contractor.	For—	Entered into.	Remarks.
Collins & Farwell	Excavating	Mar. 1, 1889	In force.
H. D. Edwards & Co	Ship chandlery	Mar. 7, 1891	Closed October, 1891.
R. G. Ferguson & Co	Zinc and galvanized iron	June 15, 1891	Closed July, 1891.
Hughes Bros. & Bangs	Building masonry	Feb. 9, 1891	In force.
George Kemp	Coal	Mar. 7, 1891	Closed December, 1891.
Jno. H. Killmaster & Co	Timber and plank	May 1, 1891	Closed September, 1891.
King Iron Bridge & M'f'g Co	Gate anchorages	Oct. 29, 1891	Closed June, 1892.
Chas. Hebard & Son	Lumber and shingles	Mar. 7, 1891	Closed January, 1892.
P. M. Church & Co	Ship chandlery	Mar. 25, 1891	In force.
James R. Ryan	Delivering clay	Nov. 28, 1891	Closed February, 1892.
John P. McGuire	Valve frames and valves	Mar. 10, 1891	In force.
Richards & Co, limited	Chemicals	Mar. 25, 1891	Closed May, 1892.
R. G. Ferguson & Co	Hardware	do	Do.
James Strachan	Machine work	do	In force.
Chas. Hebard & Son	Lumber and shingles	do	Do.
George Kemp	Coal	do	Do.

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PROGRESS MADE DURING THE FISCAL YEAR ENDING JUNE 30, 1892.

Under the Collins & Farwell contract but little was done. The contractors stopped the work of excavation on July 8, 1891, and made no attempt either to make good with concrete the excessive excavation, or to complete the filling behind Fort Brady, both of which were required by the terms of their contract.

Under the contract of Hughes Brothers & Bangs work on the masonry of the lock walls has been pushed with vigor. They have a fine plant in use at the canal and at the Drummond Island Quarries. A description of it is given in detail in the appended report of Assistant Engineer E. S. Wheeler. Although the information is not at hand for the preparation of a similar description of their plant at the Kelly's Island Quarries, yet I know, from personal inspection, that it is quite in keeping with the rest of it.

During the fiscal year the following quantities represent the work done:

	Cubic yards.
Excavation:	
In lock pit	3,161
For pump well	2,603
Total	5,764
Concrete:	
For foundations of lock walls	7,970
Between backing and rock face of excavation	244
Walls of pump well	264
Total	8,478
Cut stone laid	2,242
Backing stone laid	7,305

Of the backing stone laid the contractors furnished 6,591 cubic yards and the Government furnished 714 cubic yards, the latter being stone saved from the walls of the old State locks (of 1855).

	Pieces.
Kellys Island stone in "the rough"—	
Received July, August, September, and October, 1891	1,912
Received April, May, and June, 1892	3,033
Total received during fiscal year	4,945

Which were carried in thirty-seven cargoes.

The largest stone contained 183 cubic feet, and weighed about 14⅛ tons. After being cut its volume was 105.26 cubic feet and the weight was reduced to about 8¼ tons.

Kellys Island stone "cut"—		
During fiscal year	pieces	2,414
Containing	cubic yards	3,229¾

Gate anchorages—all have been delivered at the canal, the weight being about 275 tons.

Cement received and used—	Barrels.
Portland	2,159
Natural	19,200
Total	21,358

One additional cement house was built.

PRESENT CONDITION OF THE WORK.

Cofferdam.—The process of "stock-ramming" the clay wall of the cofferdam was continued throughout the year with great confidence in its efficacy. The operation is described in detail in the appended report of Assistant Engineer E. S. Wheeler. The party engaged upon this

part of the work does nothing else, because the dam is so vital to the other operations that it demands and receives unremitting attention. About 6 cubic yards of clay are rammed into the dam each working day. The dam is now as tight as it ever was, and the leakage through or immediately under it is remarkably small.

Pumping plant.—The water which is now pumped from the lock pit comes almost entirely through seams in the rock, and from that wasted in the operations connected with the construction of the lock. The pumping plant in position for the purpose of keeping the lock pit free has not been required to operate one-fourth of the time during the fiscal year. It is not liable to get out of order, and the greatest danger to be apprehended is from fire which might consume the buildings which house all but the 8-inch piston pump. For greater precaution this has been placed in the pump well of the new lock, at a distance from the buildings containing the other pumps.

There are four cement houses, all in excellent condition, with a capacity for the storage of 8,200 barrels of cement at one time.

Masonry.—The first stone was laid in the lock September 2, 1891. The stonecutting for the first five courses is practically completed, with the exception of the piers under the miter wall of the upper lock gates and the stone for the main miter wall. Work on the sixth course is well advanced.

The greater portion of the south face wall of the lock is built five courses high and the backing completed to correspond. In like manner the greater part of the opposite wall has been carried four courses high. Two courses in the bottom of these walls are laid throughout nearly their whole length, but portions are not yet backed. The courses are uniformly 2 feet high, except the lower course downstream from the "drop" in the lock floor, which course is 1½ feet thick. Parts of the two lower courses of the upper guard gate miter wall have been laid.

Pump well and pumping plant.—The concrete walls of the present well have been carried up to the level of the lock floor and the intake thereto from the lock chamber is completed. The preparation of the plans for the pumping plant has been intrusted to Mr. Julian Kennedy, of Pittsburg, Pa., and he now has them under consideration.

Lock gates.—The designs for the lock gates are being prepared in this office, and are now well advanced.

Gate anchorages.—The anchorages for the ten gates have been delivered at the canal. The anchor plates and the lower series of eyebars for the lower guard gates have been set in place. They are in keeping with the massive character of the whole work. The anchorages have a total weight of about 275 tons, costing, at the contract prices, $20,768.53.

Valves and valve frames.—These are under construction in accordance with a contract entered into March 10, 1892, with John P. McGuire, of Cleveland, Ohio. The contract provides for 14 valves and 12 valve frames, the estimated weight of the whole being nearly 136 tons, and will cost, at the contract price, $26,862.96, subject to a slight variation, however, in case any modifications are made during the process of manufacture.

Valve and gate engines.—The designs for these are in course of preparation in this office, and the drawings are well advanced.

Deepening the canal prism.—In accordance with advertisement dated June 2, 1892, proposals will be opened on July 2, 1892, for deepening the canal prism from a cross section about 275 feet west of the western

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end of the cofferdam, excluding, however, the site occupied by the movable dam, which it is not intended to disturb at present.

WATER LEVELS.

Daily water gauge readings above and below the locks were continued during the year, and the annual means for the calendar year 1891 and the monthly means for the various months in the fiscal year have been computed and added to the water-level tables appended to my annual report for 1890. In order that these published tables may be kept up to date, the various monthly and annual means are submitted herewith, and are as follows:

Elevations above sea level.

Month.	Lake Superior.	St. Marys River.	Lake Huron.
	Feet.	*Feet.*	*Feet.*
July, 1891	601.292	582.760	580.43
August, 1891	601.304	582.792	580.33
September, 1891	601.238	582.617	580.14
October, 1891	601.294	582.516	579.77
November, 1891	601.185	582.354	579.46
December, 1891	600.920	582.209	579.40
Annual mean	601.042	582.694	580.03
January, 1892	600.815	582.518	579.42
February, 1892	600.457	582.465	579.36
March, 1892	600.277	582.475	579.42
April, 1892	600.429	581.794	579.50
May, 1892	600.940	582.037	579.63
June, 1892	601.300	582.530	580.16

Difference in elevation.

Month.	Between Lake Superior and Lake Huron.	Between Lake Superior and St. Marys River.	Between St. Marys River and Lake Huron.
	Feet.	*Feet.*	*Feet.*
July, 1891	20.86	18.532	2.33
August, 1891	20.97	18.512	2.46
September, 1891	21.10	18.621	2.48
October, 1891	21.52	18.775	2.75
November, 1891	21.72	18.831	2.89
December, 1891	21.52	18.711	2.81
Annual mean	21.01	18.348	2.66
January, 1892	21.40	18.297	3.10
February, 1892	21.10	17.992	3.11
March, 1892	20.86	17.802	3.06
April, 1892	20.93	18.635	2.29
May, 1892	21.31	18.903	2.41
June, 1892	21.14	18.770	2.37

Drawings showing the water-level curves for lakes Superior and Huron, the former platted from observations taken above the locks at the canal, from January, 1889, to date, the latter from observations taken at Sand Beach, Mich., during same time, are also submitted.*

Miscellaneous.—The series of characteristic photographs of the work in progress has been kept up. The negatives become the property of the Government and are preserved with the records.

The work is under local charge of Assistant Engineer E. S. Wheeler, who was aided by Assistant Engineers Joseph Ripley and J. L. Callard,

* Not printed.

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Clerk Richard Common, Inspectors F. H. Reed, Rohnert, Sabin, Shenehon, Dixon, and Birton Reed, Draftsman Mangelsdorf, Subinspectors Fleming, Conkling, Spencer, Porter, Pomeroy, St. John, Barnes, Reals, Fowle, and Johnson, who were severally employed as stated in Mr. Wheeler's detailed report, hereto appended, to which attention is invited, as containing much specific information necessarily omitted from this.

Estimates.—The masonry construction is not yet sufficiently advanced to warrant letting contracts for the culverts and lock floor. It is possible that this may be done sometime during the season of 1893, and, if possible, contracts should at the same time be entered into for the lock gates and operating machinery, pumping plant, engine house, etc. In the meantime the cofferdam must be maintained, and possibly a shorter interior one built as a safeguard. The lock pit must be kept free from water; provision made for paying very considerable estimates on account of the contract for deepening the canal prism, and, in view of the importance of the most energetic prosecution of the work, an estimate of $2,000,000 is submitted, as the conditions now existing require that this amount should be available in addition to that on hand at the date of this report.

A comparative statement of the amount and value of the commerce through St. Marys Falls Canal for the calendar years 1890 and 1891 was printed as House Ex. Doc. No. 18, Fifty-second Congress, first session.

The commerce for the fiscal year just closed, as given in the report upon operating and care of the canal, shows that 11,557 vessels, etc., aggregating 9,828,874 registered tons, and carrying 10,107,603 tons of freight and 25,697 passengers, passed through the canal in 5,615 lockages, an increase over the preceding fiscal year of 2,016 vessels, 2,397,451 registered tons, 1,768,622 tons of freight, and 1,001 lockages.

When it is considered that this enormous traffic of the canal is dependent upon the single lock, the importance of pushing the enlargement of the canal to completion as soon as possible becomes manifest. Two million dollars can be expended to advantage during the fiscal year ending June 30, 1894.

Total expenditures to June 30, 1891	$587,676.74
Expended during fiscal year (exclusive of outstanding liabilities)	230,426.64
Total expenditures to June 30, 1892	818,103.38

The work is in the collection district of Superior, Mich. The nearest port of entry is Marquette, but Sault Ste. Marie is a subport. The nearest light-houses are the beacons on the western end of the canal; and Fort Brady is within half a mile.

Money statement.

July 1, 1891, balance unexpended		$2,187,335.44
June 30, 1892, amount expended during fiscal year		255,412.19
July 1, 1892, balance unexpended		1,931,923.25
July 1, 1892, outstanding liabilities	$96,080.79	
July 1, 1892, amount covered by uncompleted contracts	1,093,605.47	
		1,189,686.26
July 1, 1892, balance available		742,236.99
Amount (estimated) required for completion of existing project		2,238,865.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		2,000,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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Appropriations for improving St. Marys River, Michigan.

August 5, 1886	$250,000
August 11, 1888	1,000,000
September 19, 1890	900,000
March 3, 1891, sundry civil bill	600,000
Total	2,750,000

Abstract of bids for furnishing ten gate anchorages for the 800-foot lock at St. Marys Falls Canal, Michigan, received and opened on October 19, 1891, in accordance with advertisement dated September 19, 1891.

No.	Name and address of bidder.	Wrought steel, rolled shapes, etc. (210,240 pounds), price per pound.	Cast iron (332,188 pounds), price per pound.	Total.	Remarks.
		Cents.	*Cents.*		
1	The King Iron Bridge and Manufacturing Co., Cleveland, Ohio.	5	3	$20,477.64	Recommended for acceptance.
2	The Walker Manufacturing Co., Cleveland, Ohio.	$6\frac{1}{10}$	$2\frac{1}{2}$	21,129.34	
3	Keystone Bridge Co., Chicago, Ill.	$6\frac{34}{100}$	3	23,336.90	Informal as to signature to bid; not witnessed.
4	Phœnix Iron Co., Trenton, N. J...	$6\frac{9}{10}$	$2\frac{7}{10}$	23,475.64	Informal as to certificate; not signed.
5	Russel Wheel and Foundry Co., Detroit, Mich.	$7\frac{7}{10}$	$2\frac{85}{100}$	25,589.40	
6	W. F. Hopkins, St. Louis, Mo.....	$7\frac{9}{10}$	$2\frac{97}{100}$	26,474.94	
7	The Passaic Rolling Mill Co., Paterson, N. J.	$6\frac{1}{2}$	$4\frac{1}{2}$	28,614.06	
8	Dry Dock Engine Works, Detroit, Mich.	$8\frac{1}{2}$	$3\frac{1}{2}$	28,666.51	
9	Willard S. Pope, Detroit, Mich	$10\frac{1}{4}$	$3\frac{1}{4}$	32,345.71	Informal as to modification of clause 15 of specification.

Abstract of bids for delivering clay for improving St. Marys Falls Canal, received and opened on November 21, 1891, in accordance with advertisement dated October 22, 1891.

No.	Name and address of bidder.	Strip and dispose of 300 cubic yards, more or less, bank measure (price per cubic yard B. M.).	Deliver 5,000 cubic yards, or more, clay (price per cubic yard).	Approximate total.
		Cents.	*Cents.*	
1	James R. Ryan, Sault Ste. Marie, Mich	$0.94	$0.47	*$2,632
2	Roper R. Whiteman, Sault Ste. Marie, Mich	.23	.57	2,919
3	William Howlett, Sault Ste. Marie, Mich	.43	.62	3,229
4	John Armstrong, Sault Ste. Marie, Mich	.74	.64	3,422
5	James Rye, Sault Ste. Marie, Mich	.42	.72	3,726
6	O'Donnell & Wynn, Sault Ste. Marie, Mich	.47	.73	3,791
7	Aaron T. & Nelson Eagle, Sault Ste. Marie, Mich	.50	.85	4,400
8	Hoel D. Rains, Sault Ste. Marie, Mich	.75	.85	4,475
9	Lipsett & Murphy, Sault Ste. Marie, Mich	.59	.89	4,627
10	Lennox & Burgess, Sault Ste. Marie, Mich	.50	1.00	5,150

* Recommended for acceptance.

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Abstract of bids for supplies for improving St. Marys River, Michigan, received and opened March 14, 1892, in accordance with advertisement dated February 23, 1892.

No.	Name and address of bidder.	Supplies.	Total.
1	R. G. Ferguson & Co., Sault Ste. Marie, Mich	Hardware	*$341.63
2	P. M. Church & Co., Sault Ste. Marie, Mich	do	345.32
3	T. B. Rayl & Co., Detroit, Mich	do	379.69
4	Hodgson & Howard, Detroit, Mich	do	†381.32
1	P. M. Church & Co., Sault Ste. Marie, Mich	Ship chandlery	*511.00
2	R. G. Ferguson & Co., Sault Ste. Marie, Mich	do	520.56
1	Richards & Co. (Limited), Chicago, Ill	Chemicals	*95.25
2	Eimer & Amend, New York, N. Y	do	104.31
1	Charles Hebard & Son, Sault Ste. Marie, Mich	Lumber	*367.50
2	J. B. Sweatt, Sault Ste. Marie, Mich	do	495.00
3	Emory D. Weimer, Ludington, Mich	do	584.60
4	Henry K. Gustin, Killmaster, Mich	do	‡615.00
1	George Kemp, Sault Ste. Marie, Mich	Coal	*1,246.00
2	Thomas C. Anthony, Sault Ste. Marie, Mich	do	1,274.00

		Machine work, per hour.					Total.
		Lathe, 100 hours.	Planer, 100 hours.	Steam hammer, 100 hours.	Bolt-cutter, 100 hours.	Power drill, 100 hours.	
1	James Strachan, Sault Ste. Marie, Mich	*Cents.* 40	*Cents.* 30	*Cents.* 70	*Cents.* 30	*Cents.* 30	*$200.00

* Recommended for acceptance. † Incomplete; no bid on sieves. ‡ Only one copy of bid submitted.

Abstract of bids for furnishing twelve valve frames and fourteen valves for the 800-foot lock at St. Marys Falls Canal, Michigan, received and opened March 4, 1892, in accordance with advertisement dated January 19, 1892.

[Total weight, 271,343 pounds.]

No.	Name and address of bidder.	Price per pound.	Total cost of twelve valve frames and fourteen valves, complete.
		Cents.	
1	John P. McGuire, Cleveland, Ohio	$9\frac{9}{10}$	*$26,862.96
2	King Iron Bridge and Manufacturing Company, Cleveland, Ohio	10	27,134.30
3	Wm. C. Colburn, Detroit, Mich	11	29,847.73
4	Southwark Foundry and Machine Company, Philadelphia, Pa	$13\frac{1}{4}$	35,952.95
5	Russel Wheel and Foundry Company, Detroit, Mich	$13\frac{4}{10}$	36,359.96
6	Wicks Bros., East Saginaw, Mich	$15\frac{48}{100}$	41,786.82
7	The Globe Iron Works Company, Cleveland, Ohio	30	81,402.90

* Recommended for acceptance.

REPORT OF MR. E. S. WHEELER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sault Ste. Marie, Mich., July 1, 1892.

COLONEL: I have the honor to make the following report of operations connected with the improving St. Marys River, Michigan, during the fiscal year ending June 30, 1892:

PUMPING PLANT.

The pumping plant remains the same as last year, namely, 1 10-inch centrifugal pump, 1 5-inch centrifugal pump, 1 10-inch piston pump, 1 8-inch piston pump. This

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plant has been used continuously during the year, keeping the lock pit dry at all times, and never being used to more than one-fourth its capacity. Three men have been employed, each standing a watch of eight hours per day; $486\frac{880}{2000}$ tons of coal have been used.

PHOTOGRAPHS AND MODELS.

Photographic views showing the progress of the work have been taken each month when work was in progress. Models of the lock of 1881 and the 800-foot lock are being prepared for the Columbian Exposition. The woodwork of these models is well advanced.

COFFERDAM.

The cofferdam has remained without any leak of any magnitude during the entire year. No repairs have been necessary except replacing two broken washers on tie rods. In November the dam was covered with brush so as to hold the snow to a depth of 3 or 4 feet during the winter, which effectually prevented the freezing of the clay. When the brush was removed in May the clay was found unfrozen.

STOCK RAMMING.

The stock-ramming apparatus has been somewhat improved and perfected since last year. The accompanying plates, Nos. 1 and 2, show it as it is now used. Plate 1 shows the apparatus at work; the 3-inch pipe driven down to the bottom in the clay is shown in section. In the figure it is represented full of cylindrical molds of clay dropped into it; the rammer is withdrawn; the workmen are upon the point of placing the rammer in the tube and forcing the clay out.

No attempt has been made to show the form that the clay assumes after being driven out of the bottom of the pipe, since no part of the dam, which has been stock rammed, has yet been examined.

The pipe is composed of several short sections, which are coupled together in the usual manner of pipe coupling; this enables the pipe to be shortened or lengthened so as to deposit the clay at any required depth. The manner of making the cylinders of clay is shown in sketch "A," Plate 2. An ordinary shovel has its blade cut and rolled into a ring a little less than 3 inches in diameter and about 3 inches in length; some of these shovels are shown in the sketch. The workman pushes the shovel into the moistened clay and forces the cylinder of clay through the ring; when the cylinder is about 1 foot long and lying on the upper part of the blade it is taken off and placed in a wheelbarrow and is then wheeled to the stock rammer and put in the tube by hand, as shown in the sketches.

The rammer is an iron rod 30 feet long and about 2¼ inches in diameter; about 3 feet of its lower end is enlarged to 2¾ inches in diameter, so that it will work easily in the 3-inch pipe.

The weight which pushes the rammer down is an ordinary pile-driver hammer and weighs about 1,900 pounds; the derrick which is used is an ordinary pile-driver. A block is so arranged at the top of the derrick that it is slipped under the hammer and holds it when it is up; this block is moved with lines from the ground; a workman with these lines in his hands is shown in Plate 1. The rammer is operated by steam; the engine for this purpose is shown in the small house in Plate 1. Seven men are required to work this apparatus.

The system which is being used this year is as follows:

The pipe is first pushed down to the bottom of the dam; about one-third of a cubic yard of clay is driven in the pipe; it is then raised about 10 feet and another third driven in; it is again raised 10 feet and the operation repeated, making 1 yard in each hole. The apparatus is then moved forward 5 feet and the operation repeated. When soft spots are found in the clay intermediate holes are sometimes driven.

This does not lift the clay, crack it, or strain the cribs any appreciable amount. After the entire length of the dam has been gone over in this way the operation is repeated a second time and even a third time; in this way the clay is constantly being compressed and no injurious strains are created at any time. The total amount of clay so rammed during the season is about 1,000 cubic yards.

LOCK-PIT EXCAVATION. CONTRACT DATED MARCH 1, 1889.

The time of completion of this contract was extended from June 1, 1890, to January 1, 1891, and on account of break in cofferdam was again extended to May 1, 1891, and extended a third time to June 15, 1891.

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The contractors, Messrs. Collins & Farwell, stopped work on July 8, 1891, without having completed the required excavation, filling, etc., as per terms of contract.

A careful survey was made in June, and levels taken every 10 feet over the lock pit, dumping ground, and the fill back of Fort Brady Pier. The levels were reduced, cross sections plotted, and check computations made for final estimate of total amount of—

Rock excavation above grade and within specified side slopes.
Rock excavation below grade.
Rock excavation outside of side slopes.
Earth excavation above grade and within side slopes.
Earth excavation outside of side slopes.
South wall removed outside of side slopes.
Earth remaining between certain cross sections.
Filling back of Fort Brady Pier.
Earth necessary to complete back of Fort Brady Pier.

A detailed report was submitted, giving all written orders issued to the contractors, a statement of methods of doing work, and amounts of final estimate, with explanations of extra amounts claimed.

RANGE TARGETS, BUOYS, ETC.

From Waiska Bay to Mud Lake. All the range targets placed by the United States or by private parties; also, all the channel buoys were located by transit intersections from two or more triangulation stations. The locations were first plotted on the maps of the St. Marys River survey of 1879 and then transferred to the lake survey charts.

LOCATION OF WRECKS.

The positions of the steamer *Pontiac*, sunk at head of Little Lake George, the *Susan E. Peck*, at the elbow, Lake George Flats, and the schooner *Helena*, at Dark Hole, were located by transit intersections.

SURVEY OF CANAL.

In February soundings were taken through the ice from the head of the canal down to the cofferdam and over the bay south of the Southwest Pier.

LOCK CONSTRUCTION.

Drawings.—The original drawings of cut stone are completed. There are 15 sheets 24 inches by 72 inches; 31 sheets, 12 inches by 40 inches; 14 sheets, 26 inches by 40 inches. Tracings have been made of 9 sheets, 24 inches by 72 inches; 20 sheets, 12 inches by 40 inches; 14 sheets, 26 inches by 40 inches.

Blue prints from the above tracings have been made from time to time as required.

Zinc patterns.—A full-sized pattern in zinc is cut for each stone whose shape is other than rectangular. During the year 215 such patterns have been cut.

DESCRIPTION OF PLANT IN AND ABOUT LOCK-PIT.

Waterworks.—The waterworks consists of a storage tank of 4,000 gallons capacity placed near the west end of the lock pit on the upper level. The water is pumped from the canal by a No. 1 Worthington pump operated by steam from the incline boiler; average water-pressure gauge, about 70 pounds. Service pipes are laid on either side of the lock pit; these are tapped at suitable distances for the attachment of hose.

Tramways.—About 7,725 feet of tramway, 3-foot gauge, has been laid in and about the lock pit. This consists of a double track extending the whole length of the work, provided with necessary side tracks, crossings, and switches. A Lidgerwood double-drum, double-cylinder hoisting engine is placed at the head of each incline.

Cars.—There are in use for transporting material into the lock pit 40 platform cars of 10 tons capacity each.

Traveling cranes.—Eight traveling cranes, four on each side, have been placed in the lock pit for laying the stone in place on the lock walls. They were built by the McMyler Manufacturing Company. Length of boom, 54 feet. Four of these are of 10 tons capacity each when the boom is swung at a radius of 33 feet, and are operated by 12-inch by 14-inch double-drum, double-cylinder engines. The other four are of 5

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tons capacity each and are operated by 9-inch by 12-inch double-drum, double-cylinder engines. They are of 16-foot gauge and travel on 5-inch rails laid on trestles built to the level of the top of the first course of masonry.

Stationary steam derricks.—Four steam derricks are used for unloading stones from barges and scows and loading them on the cars for shipment into the lock pit. Two of these, one at each end of the work, are provided with turntable and steam swinging attachment. Each derrick is operated by an 8¼-inch by 10-inch double-drum, double-cylinder Lidgerwood engine. They are all of the same size and make; booms 50 feet long; mast, 68 feet high; two stiff legs, each 66 feet long, supported by A frames 34 feet long.

Horse-power derricks.—There are now being assembled on the north side of the north wall at the east end four stiff-legged derricks, each having a 35-foot mast and a 50-foot boom, and will be operated by single-drum horse-power hoists. These are to supplement the traveling cranes in laying backing stones on the wide wall. A similar derrick is placed at the pile of Government backing stone (face stone taken from the old State lock) for the purpose of loading them on the cars for shipment into the lock pit.

Rock-crushing plant.—The rock-crushing plant consists of two Gage rock-crushers, a No. 2 and a No. 4. They are operated by two horizontal boilers and engines. The crushers are on the north side of the lock pit.

Sand scow.—The sand scow is 100 feet long and 34 feet wide and is provided with a No. 6 sand pump and a rotary engine.

A small derrick is used for unloading the sand near the head of the west incline. It is operated by a small rotary engine.

Tug and scows.—The tug *Arthur*, of the Moiles line, is chartered by the season. She is employed in towing sand scow, pumping sand, towing scow laden with cut stone from the stone yard to the place of unloading for shipment into the lock pit, and other necessary work. She also makes a weekly trip to the Drummond Island stone quarry. Three scows are used in carrying cut stone.

Miscellaneous plant.—Besides the above enumerated plant there is a large miscellaneous plant, engine houses, shops, tool houses, duplicates of various parts of machinery, horses, harnesses, dump carts, wheelbarrows, tools, etc.

LOCK CONSTRUCTION.

Messrs. Hughes Bros. & Bangs began grading and laying tracks, assembling machinery, and other preliminary work on May 1, 1891, but the work of actual construction was not begun until June 24, when the first batch of concrete was laid.

Concrete.—The stone used for the concrete was the sandstone from the lock-pit excavation. An inspector was stationed at each crusher to see that good stone was used. On leaving the crusher the broken stone passed through a revolving screen 8 feet long and 2 feet in diameter, the openings in the screen being about three-eighths of an inch square, so that not the dust alone, but a considerable portion of the smaller pieces of stone were removed. The crushed stones were thoroughly washed when loaded into dump carts to be taken to the mixing boards.

Point aux Pins sand is used both for the concrete and for the laying of the masonry; it is pumped from the bottom at a short distance from shore, and is a good quality of sand, even-grained, coarse, sharp, and clean.

The concrete for the foundations of the lock walls is laid to a line 3 feet out from the face of the masonry, to insure against crushing the edges. The average thickness of the concrete for the foundations of the lock walls is about 3 feet. The greater part of the concrete was laid in the following manner: Three mixing boxes for each gang were placed side by side on the completed concrete, their forward ends being even with the front edge of the concrete. An area about 15 feet long and the full width of the foundation to be laid was then prepared by having all loose and disintegrated rock removed, the surface washed with a stream of water from a hose, and while wet a thin coating of mortar applied and rubbed in with a broom to insure the filling of all cracks in the rock and a good bond between the concrete and the rock.

The concrete was of one part Milwaukee natural cement, one and one-half parts sand, and four parts broken stone. A batch consisted of 5.25 cubic feet of cement, 7.88 cubic feet of sand, and 21 cubic feet of broken stone. The sand was spread evenly over the bottom of the mixing box and the cement spread evenly on top of it. The cement and sand were first thoroughly mixed dry and then into a rather stiff mortar. The mortar was spread evenly over the bottom of the mixing box and the stones spread over it. The stones and mortar were then mixed by four shovelers, first casting in and then casting out again. When carefully done the two castings were sufficient to insure a thorough mixing, but this largely depended upon the skill of the shovelers. The concrete was then cast direct from the boards into place,

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in layers of about 8 inches, and carefully rammed. When the concrete was laid to grade over the prepared area, the mixing boxes were pulled ahead and another section carried up in the same manner, and so repeated.

An inspector was stationed at the mixing boxes to see that the proper proportions of component materials were used and properly mixed. An inspector was also stationed to see that the surface of the rock was carefully prepared and the concrete properly placed and rammed. Tests were made to determine the voids in the broken stone; samples were taken from both crushers at different times and gave a percentage of about 46.5. These tests were made with the stones lying loose in the vessel just as shoveled in. Had they been rammed to the same amount as the concrete when laid in place no doubt the percentage would have been somewhat less. It was found from tests carefully made that 5.48 cubic feet of natural cement, 8.22 cubic feet of sand, and 2.93 cubic feet of water, when mixed, made about 9.80 cubic feet of mortar, and this mixed with 21.9 cubic feet of broken stone made about 23.5 cubic feet of concrete when rammed, showing the voids filled by the mortar to be 38 per cent and an excess of 1.5 cubic feet of mortar, or 15 per cent more than was necessary to fill the voids.

The amount of concrete made and placed during the year was 8,478 cubic yards, of which 7,970 cubic yards were for foundations of lock walls, 244 cubic yards were placed in the spaces between the backs of the walls and the rock face of the excavation, and 264 cubic yards were for the walls of the pump well. The concrete for the pump-well walls and the walls of the culvert leading from the discharge well to the pump well was made of Portland cement mixed in the proportion of one part cement, two parts sand, and four parts broken stone. A batch of concrete composed of 5.25 cubic feet cement, 10.5 cubic feet of sand, and 21 cubic feet of broken stone measured, when rammed, 0.96 cubic yard.

Laying of cut stone.—The first stone was laid September 2, 1891. Laying of face stone was stopped for the season October 15 and resumed May 5, 1892. During the year 2,241 cubic yards have been laid. The mortar used is of one part of Portland cement and one part sand.

An inspector is stationed with each gang of masons laying cut stone to see that each stone is laid true as to alignment and elevation and the joints carefully filled. He also sees that the mortar is properly gauged, and records the number of barrels of cement used and number of stones laid each day, the number of the course in which the stone is laid, together with its patterns and running numbers.

Laying of backing stone.—The laying of backing stone was begun on September 11 and stopped for the season October 1; it was resumed May 7, 1892. During the year 7,305 cubic yards have been laid, of which Hughes Brothers & Bangs furnished 6,591 cubic yards and the United States 714 cubic yards.

The mortar used is of one part natural cement and one part sand. An inspector is stationed with each gang of masons laying backing stone, to see that the mortar is properly gauged, and that the stone is properly laid as to bond and joints, and that the joints are carefully filled; he also keeps a daily record of the cement used and the volume of backing furnished by the United States.

According to the specifications payment is to be made only for the volume actually occupied by the stone in the completed wall. The method followed in computing the volume of backing laid for the monthly estimate is to compute the total volume of masonry laid and from this volume deduct the volumes of cut stone laid and mortar used.

Pointing.—The pointing is being done by the United States. At the time of laying the cut stone the masons are required to rake out the face joints to the depth of about 2 inches. After the mortar has hardened the joints are carefully pointed with mortar composed of two parts Portland cement and one part of fine sand passed through a No. 40 sieve and thoroughly washed. The mortar is mixed as dry as it can be well worked. A calking iron and mallet are used in filling the joints and a steel beading tool to make and polish the bead.

Pump well.—The pump well was excavated by Hughes Brothers & Bangs under a special contract. The excavation is 30 feet long and 28 feet wide, and the elevation of the bottom is about 543.5 above mean sea level, Total amount of material excavated, 2,602.8 cubic yards. A timber frame was erected and faced with sized planking to form the mold for the faces of the concrete walls of the well and the inlet culvert. The planking was covered with a coating of mortar about one-fourth of an inch thick just at the time of placing the concrete, to insure a smooth face; in the culvert the coating of mortar is increased to 6 inches in thickness.

The concrete walls of the well are 4 feet thick and are at present built to the level of the concrete foundation for the lock wall.

Enlargement of lock pit.—On account of extending the wide walls to the westward 18 feet at both ends of the lock pit, it was necessary to enlarge the lock-pit excavation. This was done by Hughes Bros. & Bangs, under a special contract. There was

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also included in this contract the removal of some soft material and shattered rock between the upper guard-gate miter wall and the west end of the lock pit. Total amount excavated under this contract up to date, 3,161 cubic yards. This work is not yet completed.

Backing-stone quarry.—The backing stone is brought from Drummonds Island. Hughes Bros. & Bangs leased the ground from Mrs. Johnson and developed the quarry. It is located about midway between the quarries from which was obtained the backing stone for the old State lock and the lock of 1881. It has a face 700 feet long and 30 feet high, of which 1 foot is earth stripping, 16 feet is of mixed stone, only certain strata of which can be used, and 13 feet of good stone.

The stone is a compact, bluish gray, crystalline limestone, having a conchoidal fracture, and weighs about 170 pounds per cubic feet.

Plant at quarry.—Hughes Bros. & Bangs have built a good substantial pile dock 250 feet long and 75 feet wide in 14 feet of water, and an approach to the dock 700 feet long and 30 feet wide.

On the dock are two steam derricks to unload the stone from the cars and load them on the scows. These derricks are of the same make and size, and are operated by the same-sized engine as those used for unloading stone at the lock.

There are nine derricks for handling the stone in the quarry. These are all operated by single drum horse-power hoists.

A double track is laid from the dock and extends the whole length of the quarry, with all necessary side tracks, crossings, and switches. There are also all tracks necessary for disposing of earth strippings and refuse stone. There are in use twelve platform cars of 10 tons capacity each and thirty dump cars. Five barges and scows are required to transport the stone from the quarry to the lock. There have been built five boarding camps, one hospital, one ice house, and one blacksmiths' shop.

Gate anchorage.—The gate anchorages were furnished by the King Iron Bridge and Manufacturing Company, Cleveland, Ohio, and consists of 40 anchor castings, 112 saddle castings, 240 eyebars, 40 eyebolts, 160 pins, 4 wrenches, and 1 box of washers.

The eight anchor castings for the lower guard gates, together with the two eyebars attached to each, have been placed in position in the lock walls.

CUT STONE.

The stone-cutting has all been done on the canal lands. The stone used was transported from Kelly Island in the rough, the first cargo arriving in the schooner *Fred J. Dunford*, July 17. The area occupied by contractors for stone yard was a strip of land about 1,100 feet long and 150 feet wide, lying just back of the Fort Brady Pier.

The plant used consists of two stiff-leg derricks of 15 tons capacity each, one McMyler traveling crane, four stone planers, manufactured by the Rutland Iron Works, of Vermont; a 100 H. P. automatic cut-off engine, and boiler for driving the same. The stiff-leg derricks are placed at each end of the yard, 18 feet from the face of the pier, and have booms about 50 feet long. The booms can make a complete revolution and are raised and lowered by steam. Three-fourths inch wire cable, spring hoist, and swinging gear are used on each. The track for the traveling crane is about 70 feet from the face of the pier and 1,000 feet long. It runs between the two stiff-leg derricks. A 5-inch rail and 16-foot gauge are used. The McMyler crane can travel 600 feet per minute, although its usual speed is about 400 feet. Its reach is 50 feet from the center line of track, at which point it is able to raise 4 tons, which is about the weight of the ordinary header or stretcher in the rough. It is supposed to be able to lift a load of 10 tons when situated not more than 30 feet from the center line of the track. The machinery for planing stone is situated in the center of the yard. The four planers are completed and two of them in operation, but the shafting, belting, and minor fittings will not be completed before July 7. At the present rate of progress the entire plant will be ready for operation by that date.

The construction of these machines is similar to that of an iron planer. Work on the foundations was begun April 1. The first machine was completed May 11. The second June 6, and the third and fourth June 30. The yard is lighted by electricity, the traveling crane and planers being worked night and day. The capacity of the planers can not be determined at this date, as they are not yet fully equipped. All of the machinery is suitably housed. The office, pattern room, storeroom, and blacksmith shop are in one building, situated near the center of the yard. The entire plant in yard has been erected during the fiscal year.

The contractors began cutting July 30 with a force of 25 cutters, and continued until November 30, with the exception of a delay from the 9th to 12th of September, when work was practically suspended for want of stone, one of the vessels having been delayed. The number of cutters employed did not exceed 70 at any time, the average being 47. The work of cutting was resumed April 5 with a force of 31 cut-

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ters and continued to the end of the fiscal year, with one delay from June 1 to 12, when the cutters, about 85 in number, struck for 45 cents per hour. Up to that time they had received 40 cents. A compromise was finally effected at 43 cents. The greatest number of cutters employed at any one time was 98, the average for the fiscal year being 50.

At present 3 foremen, 95 cutters, 10 planer men, 2 assistants, 3 blacksmiths, 2 helpers, 6 enginemen, 2 firemen, 6 carpenters, 1 watchman, and 22 laborers are employed in the yard, making a total of 152 men.

The following table gives a synopsis of the stone cut:

Date.	Number of pieces.	Volume.	Date.	Number of pieces.	Volume.
1891.		*Cubic yards.*	1892.		*Cubic yards.*
August	256	319.34	April	177	249.29
September	401	537.11	May	463	624.89
October	401	549.58	June	459	594.12
November	257	355.33			
Total	1,315	1,761.36	Total	1,099	1,468.30

Total number of pieces cut 2,414
Total number of cubic yards cut 3,229.66

The total number of pieces required for the lock will be about 14,309, of which there will be about 472 different patterns. Patterns of sheet zinc one sixty-fourth of an inch thick are used for all stones that are irregular in form. The first scow load of cut stone was sent to lock pit August 30. About 450 pieces of cut stone remained in the yard during the winter.

They were piled four deep and three abreast. The space between the beds, which was calked with hay, was 2 inches, the lewis holes being covered with a strip of plank of that thickness. The lewis holes in the top layer were filled with dry sand and covered with a thin layer of cement. The top of the pile had a 6-inch covering of manure, the sides were banked lightly with same, while the north, east, and west sides were protected by boards.

The following table shows the amount of stone in the rough received:

Date.	Number of loads.	Number of pieces.	Date.	Number of loads.	Number of pieces.
1891.			1892.		
July	2	286	April	2	333
August	3	377	May	11	1,354
September	4	536	June	10	1,346
October	5	713			
Total	14	1,912	Total	23	3,033

The largest stone received contained in the rough 183 cubic feet, weighing about 28,797 pounds; when cut it contained 105.26 cubic feet, weighing 16,563 pounds. It will probably be the largest stone in the lock.

A cargo of 106 pieces of stone in the rough were computed, in order to determine the amount lost in cutting, with the following results:

The cargo contained 45 headers, 32 stretchers, and 29 pieces of various numbers. When cut the amount estimated as cut stone was respectively 66, 69, and 68 per cent of the stone in the rough. To this may be added the excess in length of headers or width of stretchers paid for as backing, which was respectively 3½, 7½, and 4½ per cent of the stone in the rough.

The average of the 106 pieces was: Amount of cut stone, 68½ per cent; excess paid for as backing, 5 per cent; loss in cutting, 26½ per cent.

A few tests have been made. A sample varying in weight from 15 to 30 pounds was obtained from each cargo of stone as it arrived from Kelly Island. These samples were labeled and their specific gravity obtained in order to get the weight per cubic foot.

Three-inch cubes were afterwards cut from some of the same samples and sent to the Watertown Arsenal, Mass., to be tested as to their ability to resist compression.

The specific gravity of several different kinds of stone used in this vicinity was

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found in order to compare them with that for 800-foot lock. The following table gives the results of these tests:

Classification.	Number of samples tested.	Weight per cubic foot.
		Pounds.
Face stone for 800-foot lock, from Kelly Island	38	157.36
Backing for 800-foot lock, from Drummonds Island	2	170.31
Face stone for lock of 1881. Samples taken from the pile of rejected stone	3	154.79
Face stone for the old State lock	3	153.96
Potsdam sandstone, from excavation for 800-foot lock	3	157.50
Face stone for lock at Sault Ste. Marie, Ontario, a limestone from Amherstburg	3	147.71
Backing for lock at Sault Ste. Marie, Ontario, a limestone from Manitoulin Islands	2	175.50

Of the stone from old State lock one sample was very light, weighing only 143.12 pounds per cubic foot. Rejecting this the weight of the other samples would average 159.38 pounds per cubic feet.

The samples of the Potsdam sandstone from lock pit were close grained and hard.

The statement sent from the Watertown Arsenal shows the ability of the face stone for the 800-foot lock to resist compression to be as follows:

Test number.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
5663	0	2.98	2.98	2.98	8.88	105,800	105,800	11,910
5664	1	2.99	2.99	2.99	8.94	115,280	115,280	12,890
5665	3	2.98	2.99	2.98	8.88	112,490	112,490	12,670
5666	4	2.95	3.00	2.98	8.94	58,000	74,100	8,290
5667	6	3.00	2.97	2.97	8.82	89,000	96,900	10,980
5668	17	2.98	2.98	2.98	8.88	111,260	111,260	12,530
5669	22	2.97	2.96	2.99	8.85	111,590	111,590	12,610
5670	27	3.00	2.98	2.98	8.88	117,200	117,200	13,200
5671	30	2.98	2.98	2.99	8.91	128,200	129,300	14,510

Average ultimate strength 12,177 pounds per square inch. The compressed surfaces were faced with plaster of Paris.

The stone cutting for the first five courses of masonry is practically completed with exception of the piers and main miter wall. A few stone for the piers have been cut, but none for the main miter wall. Work on the sixth course is well advanced.

The stone planers leave a very smooth surface, and all work coming from them that is to be in contact with cement is afterwards bush hammered in order to insure a proper bond.

Sub-Inspector L. Fleming has prepared the following estimate of the cost of the plant in place at the close of the season of 1891:

No.	Name of plant.	Cost.
1	Rock-crushing plant	$3,715.44
2	Water works	602.50
3	Inclines and track	8,723.24
4	Tool and engine houses	403.39
5	Cars	2,311.57
6	Steam derricks (permanent plant)	11,655.02
7	Horse-power derricks	202.62
8	Sand scow and pumping plant	2,159.01
9	Trestles in lock pit	3,939.50
10	Traveling cranes	26,000.00
11	Plant not otherwise enumerated and labor account construction	12,354.60
	Total cost of plant at lock pit	72,066.89

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CEMENT.

Cement has been received from the contractors and used during the year as follows:

	Barrels.
Portland	2,159
Natural	19,322

A fourth cement shed has been built, making a total storage room provided by the Government of 8,200 barrels.

The following item upon cement tests has been prepared by Inspector Sabin:

The report of Gen. Gilmore's committee of the American Society of Civil Engineers on a "Uniform system for tests of cement" has been taken for a basis as far as I have been able to interpret it and the tests made in conformity with my preliminary report of January 5, 1891, which was approved.

Although the report of Gen. Gilmore's committee has done much towards advancing uniformity in apparatus, and methods in use in this country there is still much to be desired in this direction, and considerable experimental work is being done in some of the best equipped laboratories of the United States with a view to placing the testing of cement on a truly scientific basis.

The methods and apparatus as applied here are described below:

COLOR.

The color of each brand of cement is carefully observed. This is done principally as a matter of record. It is possible that some importance attaches to color, but the interpretation is by no means simple or certain. Variations in shade in the same brand may have a slight significance, but different brands may be very similar in color and differ widely in quality, and vice versa.

With natural cements a prejudice seems to exist among masons for a dark-colored cement, but some of our best results are obtained with the lightest cements.

WEIGHT PER CUBIC FOOT.

The apparatus used for obtaining the weight per cubic foot is shown in Fig. 1.* It is similar to that used on the Boston main drainage works by Mr. E. C. Clarke, and consists of a large tube through which the cement has a clear fall of 2 feet into a box holding one-eight of a cubic foot, the box being carefully struck off level when full. The cement is passed through a coarse sieve at the top of the tube. With the greatest care this apparatus does not give satisfactory results. Another form, which is described by M. Paul Alexandre in Annales des Ponts et Chaussées, for September, 1890, was also tried, but it did not prove accurate.

However, this test is fast falling into disuse since it is now well known that the value of a cement does not vary closely with its weight per cubic foot, which is influenced by fineness, burning, composition, and age, the last of which is seldom known.

SPECIFIC GRAVITY.

This is a test which has long been known, but which has not come into general use. It is described by Mr. F. J. Bramwell, in Mr. John Grant's work on "Strength of cement," but has seemed to receive little attention from engineers. This apparatus consists of a bottle fitted with a burette graduated in C. G. from 0 to 50, the zero end down; the bottle is filled with turpentine which is made to rise in the tube to 0. One hundred grams of cement are then added by means of a funnel, care being taken that it is not put in too fast. The burette is then read and the number of grams of cement, 100, divided by the burette reading gives at once the specific gravity of the cement. This test is of much greater value than the weight, per cubic foot test, because it is influenced but slightly by the fineness, and the method of filling the measure, which is so perplexing a problem in obtaining the weight per cubic foot, is simple enough in obtaining the specific gravity.

Another valuable test which is made in connection with the last is the test of the burning. After the cement has settled leaving the turpentine clear in the burette it is turned off, the burette is removed and the contents of the bottle thoroughly shaken until the 100 grams of cement are again in suspension. It is then allowed to settle and if a portion of the cement is underburned it will appear on the surface and be indicated by its yellow color.

* Not printed.

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FINENESS.

Some difficulty has been experienced in obtaining sieves suitable for use in sifting cement and sand. Five wire cloth sieves were first received marked Nos. 20, 30, 50, 80, and 100. Upon counting, the meshes per linear inch each way were found to be as in Table 1.

TABLE 1.

Number of sieve.	Meshes per linear inch.	
	Across web wires.	Across woof wires.
20	20	19¼
30	30	28¾
50	50	37¼
80	80	67
100	100	89

Sieves whose meshes should be more nearly accurate to count were asked for to replace the last four numbers. The manufacturer said no complaint had ever been made before, but sent four sieves of the same make whose meshes counted as given in Table 2.

TABLE 2.

Number of sieve.	Meshes per linear inch.	
	Across web wires.	Across woof wires.
30	30	28¼
50	50	34¼
80	80	67
100	100	90

The No. 100 was a trifle better as to count, but the meshes appeared to be more irregular than those of the first No. 100.

Of the third lot received the last three were of a different style. It was explained that they had been procured of a "party in New York who claimed to have had the cloth made especially for such work." Table 3 gives the results for this lot.

TABLE 3.

Number of sieve.	Meshes per linear inch.	
	Across web wires.	Across woof wires.
30	30	28½
50	50	47
74	80	80
100	101	88½

The diameters of the wire in some of the sieves were measured with a microscope fitted with a micrometer attachment. Results are given in Table 4.

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TABLE 4.

Number of sieve.	Number of meshes per linear inch.		Diameter of wire in decimals of an inch.					Mean size of opening in decimals of an inch.			
			Web.		Woof.						
	Across web wires.	Across woof wires.	Number of results averaged.	Diameter.	Number of results averaged.	Diameter.	Difference.	Between web wires.	Between woof wires.	Difference.	
20	20	19¼	4	.0185	4	.0169	.0016	.0315	.0337	.0022	.93
30	30	28¾	4	.0119	4	.0119	.0000	.0214	.0229	.0015	.93
50	50	47	2	.0082	2	.0083	.0001	.0118	.0130	.0012	.90
74	80	80	2	.0054	1	.0054	.0000	.0071	.0071	.0000	1.00
100	101	88½	3	.0040	3	.0040	.0000	.0059	.0073	.0014	.80

It is noticed that the diameters of the web and woof wires in the No. 20 sieve differ by a very appreciable amount. This may be due to the flattening of the web wires in course of the manufacture of the cloth.

The irregularity of the meshes was tested by measuring the width of adjacent openings. In the No. 20 sieve one mesh was found whose width was but 64.2 per cent of the width of an adjacent one, and in the No. 100 sieve the widths of two adjoining meshes were as three is to four. It should be remembered that these measurements were made before the sieve had become injured by use.

If we assume that the No. 50 sieve of table 2 having 34¾ meshes per linear inch across the woof wires, to be made of wire having diameters .0083 inch, the mesh, instead of being .012 inch square, would be .012 inch by .020 inch, or only three-fifths as wide as long. That the number of meshes per linear inch should be correct is thus seen to be of greater importance than would at first appear.

The committee of the American Society of Civil Engineers, in their report on a "Uniform system for tests of cement," recommend the use of wire of Nos. 28, 31, 35, 37, and 40, "Stubbs's wire gauge." This seems to leave the diameter of the wire uncertain on account of the difficulty of determining what "Stubbs's gauge" really is. C. P. B. Shelley, professor of machinery, King's College, London, says of wire gauges: "Of late years careful comparisons have more than once been independently made with a view to ascertaining the standard value of these incongruous systems, but the discrepancies in the results only prove what might have been predicted, viz: That errors have crept in, and that those which profess to be alike differ among themselves, whilst there exists no satisfactory means of rectifying these errors." (Ency. Brit., vol. x, p. 110.) Manufacturers urge their customers to "give dimensions and not numbers." Trautwine's "Pocketbook" says: "As Mr. Stubbs makes various English gauges, the term 'Stubbs's gauge' by itself means nothing. Generally, however, in our machine shops, it applies to the Birmingham gauges." I have been informed by the members of the committee that the words "Stubbs's gauge" do mean Birmingham gauges. This, however, does not help the matter much, because Nos. 37 and 40 are not given in the Birmingham gauge. It has so far been impossible for me to determine what is the diameter of wire corresponding to "Nos. 37 and 40 Stubbs's wire gauge."

In Table 5 are given in decimals of an inch, the diameters of wire corresponding to Nos. 28, 31, 35, 37, and 40 in a few of the many "standard" gauges, and in last two columns the actual diameters of wire as found in cloth purporting to be made of wire of corresponding number. It should be stated that manufacturer A does not claim to be using "Stubbs's gauge," while B does.

TABLE 5.

No. of wire.	Wire gauges. Diameter in decimals of an inch.						Actual diameters of wire in sieves. Nos. 20, 30, 50, (74), and 100.	
	American or Brown C. Sharpe.	Birmingham or Stubbs.	Washburn and Moen Manufacturing Company.	Trenton Iron Company.	G. W. Prentiss.	Old English from brass manufacturers' list.	Manufacturer A.	Manufacturer B.
28	.012641	.014	.016	.016	.017	.0165	.0185 .0169	.....
31	.008928	.01	.0135	.013	.0146	.01225	.0119	.....
35	.005614	.005	.0095	.0095	.0109	.009	.0091	.0082
37	.004453	.....	.0085	.0085	.0095	.0065	.....	.0054
40	.003144	.....	.007	.007	.0078	.0045	.....	.0040

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As a result of this labyrinth in indetermination it is impossible to know, except approximately, the size of holes in sieves that have been used and are being used. An observer can measure and determine the dimensions of the holes in his own sieve, but he can not certainly know within a large percentage the sizes of the holes in sieves used by other experimenters with whom he may wish to compare.

It may not seem out of place, then, to endeavor to formulate what is desirable in a sieve and then to inquire how it may best be obtained. It is thought that the following specifications define an ideal sieve: (1) holes of uniform size and shape throughout, (2) sides of the holes very smooth, (3) space between holes of such size and shape that particles will not easily rest there.

A sieve may deviate from the ideal and still be a good one. As regards uniformity, it is evident that the largest holes determine the character of the sieve. For example, a sieve with half its holes 0.01 inch in size and the other half 0.02 in size, would, if used long enough, separate the cement exactly the same as it would if all the holes hand been 0.02 inch in size. If even a very small percentage of the holes are larger than the normal, it seriously impairs the accuracy of the sieve by introducing an indetermination. On the other hand, holes smaller than the normal have no greater objection than that, as the sifting proceeds, they become spaces between the real or larger holes, and as such do not fulfill the third specification. Therefore, while larger holes are not admissible, smaller holes may be allowed to the extent of, say, 10 per cent, and the sieve still be good and accurate. Concerning the second specification, the sides of the holes must be so smooth as not to allow particles of cement to adhere and thus clog the hole. The third requirement is for convenience, but might require consideration if the style of sieve were changed.

A punched metal plate has been suggested as a substitute for wire cloth, and is dissussed editorially in Engineering News for September 26, 1891. An objection is there made to a change in the shape of the hole. I do not see the validity of this objection. The crushed quartz, recommended by the American Society of Civil Engineers' Committee, and which is coming into use for sand tests in this country, has practically no rounded grains, and it is not probable that the *shape* of the grains passing round holes would be materially different from those passing square holes. If it is argued that there would be difficulty in adjusting the size of openings to correspond with the sizes of square holes in current use, it may be returned that sieves now in use purporting to be of the same size of mesh differ so widely that they are hardly worth serious consideration in any changes which may seem desirable. A punched metal plate could no doubt be made to fulfill the first specification almost perfectly, and would be less likely to injury from use than a wire sieve, but the former might not so fully comply with the second and third requirements. On the other hand, a wire-cloth sieve readily complies with the last two, but, as has been seen, is apt to be wide of the mark on the first. I have been informed, however, by Edward Darby & Sons, wire manufacturers, Philadelphia, that they are prepared to make "a cloth accurate in number of meshes to the inch" at an advance in price of about 30 per cent over the ordinary cloth. It is believed that though there are possibilities in the punched metal plate, yet the wire cloth should be adhered to if sufficient accuracy can be obtained by its use.

Finally, the question of sieves might be put upon a better basis if the following things were done, viz:

(1) Manufacturers of wire cloth should be encouraged to make cloth which will fulfill as nearly as may be the foregoing specifications; and

(2) Observers should be urged to designate their sieves by the *size and shape of the holes.*

TIME OF SETTING.

Gen. Gillmore's wires are used for this test, the apparatus being as simple as it can be made. The neat cement is gauged with the same percentage of water for this test as used in making briquets. Care is taken that the water and cement and the room in which the test is made shall vary only slightly, if at all, from 65° F. The effect of slight changes in temperature on the setting of cement is marked.

CHECKING, ETC.

The pats that are made for determining the time of setting are immersed, when set, to detect tendencies to expand. This test is of the highest importance, as it is manifestly better to use a cement that is sound, even if it is not very strong, than to use one of high strength that will ultimately "blow." Immersed in water of the ordinary temperature, a pat may not show signs of unsoundness until it has been necessary to issue the cement for use. It is therefore desirable that some method be found which will give certain and quick results.

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Mr. Henry Faija, an English authority, has made use of a "steamer," and immerses the pats of Portland cement in water maintained at 100° F. Some engineers in this country take 212° F. as the temperature at which the water shall be maintained. Some experiments have been made with a similar apparatus here, but not enough to warrant any statements as to its value.

TENSILE STRENGTH.

The positive test for cement is its strength, not after one, seven, or twenty-eight days, but after several years. High adhesive properties are of the greatest value. When a crack appears in masonry, it is usually between the joint and the stone. Crushing strength is also of great value, but since the tensile strength is so much less than the compressive, it seems highly probable that mortar fails oftener in tension than in compression. Therefore, it is not alone the comparative ease with which the tensile test may be made that commends it to the engineer.

The tensile test should perhaps be called comparatively less difficult rather than comparatively easy. Every step in the process must be made with the greatest care if it is hoped that a test made to-day may be compared with one made next month or even to-morrow.

The proportions most frequently used are neat cement; natural cement one, sand one; and Portland cement one, sand three, all by weight. In making regular tests only enough mortar is made for one briquet from each sample, except when making neat briquetes, when enough additional is made to allow for a pat from the same mixture. For special tests five briquets can be made from one gauging when the cement is slow setting. The amounts of material are determined in ounces, but it is expected to substitute grams at an early date on account of the greater convenience. The amount of water to be used is determined by trial mixtures. The consistency of mortar used is such that when it is tapped with the hand the moisture appears. The surface of the briquet when finished shows a little moisture. It is extremely desirable that there should be some simple way to specify a certain consistency of mortar. "Stiff plastic mortar" conveys different ideas to different men as has often been seen. It is to be hoped that an apparatus similar to Boehm's consistency apparatus will come into general use in this country. For stiff mortars the needle of wire should be rather fine.

The sand used for tests is the crushed quartz recommended by the American Society committee. The portion used is that held between sieves Nos. 20 and 30 (see Table 4 for size of holes). Several samples of this quartz were received from Baeder, Adamson & Co., Chicago, of different trade numbers. The amount retained between the two sieves mentioned were as follows: No. 3, 46 per cent; No. 3½, 29.4 per cent; No. 4, first sample, 95.4 per cent, second sample, 70.9 per cent; No. 6, 14.4 per cent. No 4 sand was ordered; the fineness varied in different barrels, from 70 to 90 per cent being retained between the two sieves.

GAUGING.

The mortar is gauged in an iron box, shown in fig. 2, with a strong German clod hoe of steel. The materials are first mixed dry and all water added at once. A wooden box made on the principle of the one used for the tests of cement for the lock of 1881 was tried for a few months. Several objections were found to the use of a wooden box. Water was always allowed to stand in it when not in use because otherwise it would have extracted water from the first few mixtures made with it after standing. But the opposite evil followed from the treatment given, the box could not be wiped so dry that it would not give up some moisture to the first mixtures and the first briquet was noticeably more moist than the others. With the very sharp sand which was used for tests the boxes wore down rapidly and new ones had to be made frequently. About July 1, 1891, two iron boxes were cast and have been in constant use ever since, giving perfect satisfaction. It was afterwards found that Mr. Noble, who, so far as I know was the first to use a wooden box of the form described, had also had boxes made of iron for the tests of cement for the Memphis Bridge. It is believed that a more thorough mix can be made in these boxes than in the wooden ones, and I consider the methods as used to be very far ahead of mixing on a slab with a trowel as is ordinarily done. A box made from our pattern was introduced into the laboratory of the Empire Cement Company by Dr. Froehling and has given, I believe, excellent results.

Our results on sand briquets have seemed to be higher than those of many experimenters, and I am inclined to attribute this largely to the perfect gauging which can be done by using sufficient muscle with this apparatus. From one and one-half to two minutes are required for gauging.

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MOLDS.

These are of the form recommended by General Gilmore's committee of the American Society of Civil Engineers, and now in general use in the United States. Fifty-three of the molds fasten with an iron clamp and the other two halves are completely separable. Forty are hinge molds with a fastening at one end. The latter are neater in appearance and occupy less space on the slab when in use, but are more difficult to clean, which is a matter of some moment when making a large number of briquets.

MOLDING.

It has been the practice to put about one-sixth of the mortar into the mold at a time and pack it in firmly with the fingers, finishing the top with a small pointing trowel. Recently I have had this method compared with the method specified by the American Society committee, which is to use the trowel for pressing the mortar into the mold. Two neat natural cement briquets were made from the same mixing, one by each method and the results of one hundred briquets at seven days show very close agreement in the two methods.

The briquets are covered with a damp cloth when made and are in general removed as soon as set. Natural briquets may generally be removed the same day, but slow setting Portlands are left in the molds over night, the cloth being well dampened. On removing from the molds the briquets are placed on metal covered as before and immersed twenty-four hours after molding.

TEMPERATURES.

The temperature of the room is kept as nearly as may be at 65° to 70° F. For this purpose a night watchman was employed all winter. Hourly readings of the thermometer were recorded during the night and a reading recorded for each set of briquets made during the day. Four readings a day were also made of the temperature of the open air where some special test briquets are exposed.

The cement and water used in gauging were also at 65° F. except in some special cases. With a very quick setting cement it was found necessary to use colder materials to allow the briquets to be moulded before signs of setting appeared.

The tanks for immersing were tiered seven high in the test room, but it was found that the difference in temperature between the top and the bottom boxes was enough to be serious and the use of the bottom three was discontinued. All the boxes are now on about the same level and have a nearly uniform temperature.

TESTING MACHINE AND CLIPS.

The briquets are broken on a Riehlé 1,000-pound machine. It has worked well, its chief objection being that it requires considerable space. A pair of pulleys with which it may be thrown in and out of gear by the feet facilitates working considerably. About 120 briquets, having an average strength of 100 pounds, can be broken in an hour without exceeding the rate of applying strain of 400 pounds, per minute.

The clips used are the Riehlé style, furnished with the machine, and are shown in Fig. 5. The briquets often break at the gripping points of the clips. It is not known exactly to what a clip break is due. It may be, and probably is, due to the briquet being subjected to compression at that point, but other theories are also advanced. The theories are not usually accompanied by an exhaustive series of tests, as this would be difficult to make. With the hope of obtaining more truthful results in breaking briquets a pair of evener clips, designed by Mr. S. Bent Russell, of the St. Louis Water Works extension, were purchased. These clips are shown in Fig. 6, and are described in Engineer News for July 3, 1891.

It has been thought by some experimenters that the insertion of a rubber strip between clip and briquet would be advisable. There is no doubt that this does away with clip breaks, but the results are lower than without the rubber. Two series of tests have been made to compare the three styles of clip mentioned. (Calling the rigid clip with rubber cushion a style by itself.) These will be reported upon when they have been reduced. At present it is sufficient to say that the rigid clip is still in use.

The rate at which the strain is applied is 400 pounds per minute, as has previously been intimated. This rate is maintained constant by means of a pendulum, in accordance with which the hand wheel is turned that moves the weight applying the strain to the briquet.

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RECORDS.

The barrels are numbered consecutively as they are tiered in the warehouses, and every barrel whose number is divisible by three is sampled for a briquet. Each sample is placed in a tin can provided with a tightly fitting cover upon which is marked the number of the barrel from which the sample was taken. The sample is supposed to fairly represent the contents of the barrel, as by means of a sugar scoop a core about 18 inches long and 1 inch section is obtained. The numbers are entered in a series of books called "barrel books" and a check is placed opposite each barrel sampled. It was the custom last year to make a pat from each barrel not sampled for a briquet, and to break them after about twenty-four hours with the hand, any breaking with less than the ordinary strain being considered doubtful and the barrel then sampled for a briquet. As was expected this test merely served to show whether the contents of the barrel was cement; and I have previously recommended that it be discontinued, and that a simple inspection of a sample be substituted. Of the samples in the cans about every tenth one is tested for fineness. It is not considered necessary to test a larger percentage than this for fineness because the cements offered for use are easily above the specifications in this regard.

Briquets are made in sets of ten for convenience. Each set is given a page in the "record book," where is recorded the following information: Kind and brand of cement, where made, when and from whom received, date of making briquets, numbers of barrels from which each briquet is made with corresponding numbers of briquets, fineness and time of setting, proportions and temperatures of materials, the temperature of the room where made, the name of the moulder and the letter of the tank where they are immersed. When the briquets are broken the date of breaking and age of the briquet are recorded on this page of the record book and the tensile strength of each briquet is filled in with remarks on each if any.

The results are copied from the record book in a condensed form to the summary book. One line of the latter contains the results given on one page of the record book. In the summary book the results of each brand are grouped so that the record of any brand as to tensile strength may be seen at a glance.

If the tests on the barrel are satisfactory the date of acceptance is entered in the barrel book opposite the number of the barrel and in the column head "accepted." Each sample is taken to also represent the two barrels preceding it, and if the rough tests on these barrels have been satisfactory it only remains to place the acceptance mark on the three barrels and they are ready to issue. The weight of each barrel with its number is recorded in a weight-book as issued and the date of issue is afterwards copied into the barrel book.

On the other hand if any of the tests on a barrel are not satisfactory it is resampled and with it is sampled the next preceding barrel which it has been taken to represent and the tests repeated. If on this second test the results are not up to the specifications the two barrels are rejected and the date of rejection is entered opposite their numbers in the barrel book in the column headed "rejected" and the remaining barrel of the group of three is submitted to a test. If, however, a large percentage of the barrels fail on the first test, the lot is rejected after making sure that this result is not due to faulty manipulation.

If rejected, the barrels are prominently marked to prevent their being issued for use, and they are removed from the warehouses as early as practicable when the date of their issue is entered, as is done with the accepted barrels. It is thus seen that the history of every barrel is contained in the "barrel book," and may be easily referred to.

RESULTS.

A few preliminary tests were made between January 15 and May 15, 1891. These were made in a room unsuited to the purpose, and the temperature varied much. The molders had not become expert. In moving the briquete to the test room provided in one of the cement warehouses above the locks the briquetes were necessarily more or less exposed to drying. This move was made about June 1, 1891, and the results from briquets made previous to that date must be accepted with caution because of the reasons mentioned. Many of these preliminary tests were made to discover, if possible, the relative values of the different sands found in this locality, and the results were given in my monthly reports. The months of June, July, August, September, and October were occupied almost entirely in making regular 7 and 28 day tests of cements offered for use. We have, therefore, broken but few briquetes whose age was sufficient to make the results of general interest.

In Tables 6 and 7 are given a few results selected with a view to their importance and interest. They are tests of sands rather than cements, though incidentally the quality of the cements may be seen. Nos. 1 to 7 show the increase of strength with age of a good quality of German cement with one and three parts of sand in use on

the 800-foot lock. This sand is from Point aux Pins, about 3 miles above the lock, and is pumped from shallow water. In general it contains but little gravel and is clean. Quite a large percentage of the grains are quartz, but they are not sharp. As to the fineness, about 11 per cent is retained on the No. 20 sieve (mentioned in Table 4), and about 75 per cent passes the No. 30 sieve. When a measure is loosely filled with dry sand the voids occupy 35 to 40 per cent of the measure.

For face stone, one barrel of Portland cement weighing about 380 pounds net is mixed with 3.75 cubic feet of sand. This amount of sand dry would weigh about 380 pounds. The weight of sand varies greatly with the moisture contained. According to recent experiments made in France the presence of 1 per cent of water in sand requires an additien of 19 per cent of sand by measure to obtain the same percentage of dry sand to cement. When the sand is perfectly dry the proportions as used on the 800-foot lock are about one to one by weight.

Nos. 8 to 10 give similar results for a different cement. Nos. 12 and 13 show excellent results for two parts Point aux Pins sand. Nos. 14 to 18 are the results of tests on several varieties of sand which could be used for pointing. The sandstone screenings were collected below the screen of the stone crusher which is crushing the Potsdam sandstone for use in making concrete. Considerable of this sand is extremely fine. About half of it passes No. 30 sieve (Table 4), 35 to 40 per cent passes No. 50, and about half of this passes No. 100. It is seen that the results are about 20 per cent higher when the finest portions are removed. The Water Power sand was obtained from open bank, is clean, but too fine for general use. Sand A is a very clean white sand with rounded grains. It is believed a similar sand was used for part of the pointing on the lock of 1881.

TABLE 6.—*Sand tests—Portland cement.*

Reference number.	Brand.	Number of barrel.	Date of making briquettes.	Molder.	Sand.		Mortar.		Age.	Number averaged.	Tensile strength.	
					Kind.	Fineness.	No. of parts of sand to one of cement by weight.	Per cent of water.			Means in pounds per square inch.	Average of the error in per cent of breaking strain.
			1891.									
1	K	3	July 17	L	Point aux Pins.	Pebbles removed.	1	12.5	7 days	5	318.4	6.0
2	K	3	July 17	L	....do	....do	1	12.5	28 days.	10	424.9	3.9
3	K	3	July 17	L	....do	....do	1	12.5	3 mos..	5	549.4	3.5
4	K	3	July 17	L	....do	....do	1	12.5	9 mos..	10	604.0	5.6
5	K	3	July 18	L	....do	....do	3	11.1	7 days	5	145.4	5.7
6	K	3	July 18	L	....do	....do	3	11.1	28 days.	10	213.6	5.4
7	K	3	July 17	L	....do	....do	3	11.1	9 mos..	9	345.7	3.0
8	R	Mixture from 10 bbls.	Aug. 22	N	....do	....do	3	11.4	7 days	5	147.4	7.6
9	R	...do.....	Aug. 22	N	....do	....do	3	11.4	28 days.	10	213.4	4.3
10	R	...do.....	Aug. 22	N	....do	....do	3	11.4	6 mos..	5	291.2	2.1
11*	R	12,186 to 12,213	Aug. 21	N	Standard	20-30.....	3	11.1	6 mos..	7	379.2	.....
12†	R	Mixture from 15,126 to 213.	Oct. 6	N	Point aux Pins.	Pass 10 ...	2	10.0	6 mos..	5	479.0	4.6
13	R	...do.....	Oct. 6	N	....do	Pass 10 ...	2	10.3	6 mos.	5	477.6	3.2
14‡	R	Mixture from 15,216 to 73.	Oct. 9	N	Sandstone screenings	Pass 40 ...	2	18.5	6 mos..	5	388.0	3.0
15	R	...do.....	Oct. 9	N	....do	40-100.....	2	17.5	mos..	5	478.2	1.0
16	R	...do.....	Oct. 9	N	Water power	Pass 40 ...	2	13.3	mos..	5	433.4	4.2
17	R	...do.....	Oct. 9	N	Point aux Pins.	Pass 40 ...	2	12.1	6 mos..	5	382.0	2.7
18§	R	...do.....	Oct. 9	N	"A"	Pass 40 ...	2	13.3	6 mos..	5	398.4	3.7

* Each briquet made from separate barrel.
† Holes in No. 10 sieve about .08 inch square. Trifle too stiff.
‡ Holes in No. 40 sieve about .015 inch square.
§ Briquets had defective edges.

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TABLE 7.—*Sand tests—Natural cement.*

Reference number.	Brand.	Number of barrel.	Date of making briquets.	Molder.	Sand.		Mortar.		Age.	Number averaged.	Tensile strength.	
					Kind.	Fineness.	No. of parts of sand to one of cement by weight.	Per cent of water.			Mean in pounds per square inch.	Average of the error in per cent of breaking strain.
			1891.									
19	Dn	5	Mar. 16	N	Bruce mines	Unsifted..	2	14.8	28 days.	7	250.0	3.5
20	Dn	5	Mar. 16	N	....do	...do	2	14.8	3 mos ..	6	411.3	8.4
21	Dn	5	Apr. 21	N	....do	...do	2	14.8	1 year..	6	423.3	4.3
22	Dn	5	Apr. 23	N	....do	...do	3	14.6	1 year..	10	316.0	8.4
23	Dn	5	Mar. 17	N	....do	Pass 20 ...	1	18.7	7 days.	6	54.5	13.8
24	Dn	5	Mar. 14	N	....do	...do	1	18.7	28 days.	6	244.8	4.5
25	Dn	5	Mar. 17	N	....do	...do	1	18.7	1 year..	7	436.6	6.2
26	Dn	5	July 3	N	Sandstone screenings.	Retained on 40.	2	16.7	7 days..	2	31.5	1.3
27	Dn	5	July 3	N	....do	...do	2	16.7	28 days.	5	202.6	8.1
28	Dn	5	July 3	N	....do	...do	2	16.7	3 mos ..	3	416.0	2.4
29	Dn	5	July 7	N	Point aux Pins.	Pebbles removed.	2	14.8	28 days.	10	169.9	5.9
30	Dn	5	July 7	N	....do	...do	2	14.8	3 mos ..	10	345.0	3.2
31*	Gn	Mixture, 1891.	Oct. 10	N	Sandstone screening.	Pass 10 ...	2	18.5	6 mos ..	5	411.8	3.3
32	Gn	...do	Oct. 10	N	....do	...do	2	20.8	6 mos..	5	395.0	1.2
33	Gn	...do	Oct.. 10	N	Point aux Pins.	...do	2	14.8	6 mos ..	10	384.3	5.0
34	En	15S	Oct. 10	N	Sandstone screenings.	...do	2	18.5	6 mos ..	10	375.2	2.6
35	En	15S	Oct. 10	N	Point aux Pins.	...do	2	13.3	6 mos ..	10	307.2	5.6
36	Gn	Mixture, 25 barrels.	Aug. 15	N	Standard	20/30.....	2	14.3	6 mos ..	10	431.8	3.5
37	Gn	2,454	July 11	N	Point aux Pins and Bruce mines, one-half each.	Unsifted..	2	14.8	9 mos..	5	445.2	5.3
38	Gn	2,454	July 13	N	Point aux Pins and sandstone screenings one-half each.	Point aux Pins unsifted s. sc. on 40.	2	14.8	9 mos ..	5	569.4	4.4

*Holes in No. 10 sieve about 0.08 inch square; mortar too stiff.

In Table No. 7, Nos. 19 to 25 show the increase of strength of a Western cement mixed with different proportions of a very coarse sharp quartz sand nearly pure, from the waste piles of the Bruce Copper Mines. Less than half of this sand passes No. 20 sieve and about one-fourth passes No. 30. The result No. 20 is seen to be very high. Nos. 26 to 28 give similar results for the sandstone screenings mentioned above, and 29 and 30 are with Point aux Pins sand, indicating that for this brand of cement the latter is not quite as good; but the Point aux Pins sand is finer, and mortar made with it would probably increase in strength more after three months than with mortar made with the coarser sands.

Leaving this brand of cement, Nos. 31 to 35 form a short series comparing two brands of natural cement when used with two quite different brands. One of the cements is Eastern and the other Western. The Eastern brand is recognized as among the best of its kind. The results indicate that the sandstone screenings are somewhat better than the Point aux Pins sand for these cements.

Nos. 37 and 38, made from the same barrel, show that the use of a mixture of two sands gives excellent results.

As has been intimated above, great care should be taken in drawing conclusions from comparing two results. When these tests were made the daily routine tests generally occupied too much time to permit of a complete series being attempted,

and in consequence the results are somewhat fragmentary. During the winter more time is available, and some of the most important work is done at that time. Series have been started as follows: To show the comparative strength of about fifteen brands of Portland cement when mixed neat and with one and three parts of sand by weight. A similar series for seven brands of natural cement, ages being seven days to four years. Several series from different barrels of the same brand for long and short time tests, made to aid in the interpretation of the regular short-time tests on the same brands. Series to show the effect of salt, the strength of brine required to prevent injury from frost, effect of heating of materials, and tests to illustrate other points which have come up in the practical use and testing of cements. Some of the briquets of a few of these series have been broken, but the results are not given, as they would now be incomplete and might be misleading.

OFFICE WORK.

In addition to the routine office work the following special work has received attention:

All the letter books used during the construction of the lock of 1881, most of which were not indexed, have been completed in this respect, and these records are now in good shape for reference.

Special report on claims of Collins & Farwell was submitted to you under date of 19th September, 1891. A special report by Subinspector L. Fleming on cost of work to Messrs. Hughes Brothers & Bangs for the season of 1891, was submitted. This is submitted as a part of the report of Clerk Common.

* * * * * * *

The items upon "excavation" and "surveys" in this report have been prepared by Assistant Engineer Joseph Ripley. The items concerning "lock" construction have been prepared by Assistant Engineer J. L. Callard. The items "office work" and "contracts" have been prepared by Clerk Richard Common. The item "cut stone" has been prepared by Inspector F. H. Reed. The item "cement" has been prepared by Inspector L. C. Sabin, and the item of "cost" of contractors' plant has been prepared by Subinspector L. Fleming.

There have been employed upon this work during the year, Assistant Engineers Ripley and Callard, Clerk Common, Inspectors F. H. Reed, Rohnert, Sabin, Shenehon, Dixon, and Birton Reed, Draughtsman Mangelsdorf, Subinspectors Fleming, Conklin, Spencer, Porter, Pomeroy, St. John, Barnes, Reals, Fowle, and Johnson.

Very respectfully, your obedient servant,

E. S. WHEELER,
Assistant Engineer, etc.

Col. O. M. POE,
Corps of Engineers, U. S. A.

REPORT OF COLONEL O. M. POE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFEICE,
Detroit, Mich., November 10, 1891.

SIR: I have the honor to submit the following report upon the recent blockade of shipping in St. Marys River, Michigan, caused by the sinking of the steamer *Susan E. Peck* in the natural channel about 550 yards below the point known as "the Elbow" at the lower end of the artificial channel dredged across Lake George Flats, about 21 miles from St. Marys Falls Canal. The exact location of the wreck is shown on the accompanying Lake Survey chart (No. 1) of river Ste. Marie.

The accident occurred about 1:10 p. m. on Saturday, October 10, 1891, by reason of a collision between the *Susan E. Peck*, bound down, laden with grain, and the schooner *G. W. Adams*, upward bound, light. While it is not assumed to fix the blame for the deplorable event, yet it seems probable that if the tow of which the *G. W. Adams* formed a part had taken the leeward instead of the windward side of the channel, the accident might not have happened.

The *Adams* was drawing less than 6 feet forward at the time, while the *Peck* was deeply laden. In consequence of these conditions the in-

jury to the latter, due to the collision, did not extend very far down, but it was sufficient to cause her to sink. In doing so she settled athwart the channel, her bow inclined downstream and resting against the very abrupt eastern channel bank in 20 feet of water, with only about 8 feet in depth just ahead of her stem, and her stern upon the western side in about 6 feet. The vessel thus became a dam directly across the channel, completely stopping the passage of all vessels drawing more than 8 feet of water, and blockading the entire traffic between Lake Superior and the lower lakes.

Information of the state of affairs was received at Sault Ste. Marie about 4 p. m., and soon thereafter Assistant Engineer E. S. Wheeler telegraphed me as follows:

The *Peck* is sunk at the "Elbow." Nothing can pass. A channel could be dredged around her.

This telegram was received by me at about 6 p. m., and an hour later Mr. Wheeler had received from me the following instructions by telegraph:

Employ enough dredges by the hour on best possible terms. Work day and night to open channel in shortest time. Dredgemen must not take advantage of emergency.

At 9:30 p. m. Mr. Wheeler wired me as follows:

Dunbar has started three dredges for wreck; $12 per hour. I leave at daylight to make examination.

At 1:45 p. m. next day (Sunday, October 11, 1891), the following telegram was received from Mr. Wheeler:

Three dredges at work. Fourth on the way. Channel will be open Thursday, 15th, or before.

The number of vessels stopped by the accident increased so rapidly that it became evident that unless action was taken by which their control should be vested in one person confusion would be inevitable, and further accidents probable, especially when the channel being dredged should become available. The vessel owners and captains present saw this plainly, and in the emergency telegraphed this office as follows:

In behalf of masters of the down-bound fleet, we would request that the canal authorities be placed in charge of vessels passing the obstruction in the Soo River.

R. R. GRAVES,
And twenty others.

This dispatch was received at 12:15 p. m., October 12, 1891, and the following instructions were at once sent to Mr. Wheeler by telegraph:

Telegram from Graves and others requests that canal authorities be placed in charge of vessels passing obstruction in river. Do what you can in the matter.

It was with a great deal of reluctance that the canal authorities took charge as requested by the vessel men. The matter was beyond their jurisdiction, and they had no legal means of enforcing obedience to such orders as might be given. But the emergency of the case was great, and it was imperative that some one should assume the requisite control. It was apparent to all that if nothing was done to preserve order, the benefits to be expected from the dredging would be greatly curtailed, if not destroyed, by an indiscriminate rush upon the part of vessels to crowd through the channel first. By concerted action of the vessel men they had evinced a desire that the representatives of the United States should assume this charge, and it was deemed advisable

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to accede. The result was almost universal satisfaction upon the part of those interested.

Mr. Martin Lynch, superintendent of St. Marys Falls Canal, with two assistants, proceeded to the point of obstruction. Two tugs were used as dispatch boats, and by visiting all waiting vessels obtained from their masters the time of their arrival respectively, and an orderly arrangement was determined upon for the passage of boats around the wreck as soon as the channel should become available.

For some distance above and below where the wreck was lying the channel is too narrow for vessels to safely pass each other, and it would have been very unwise to run the chance of another collision which would probably undo all that had already been done. It was, therefore, deemed advisable not to try to pass the vessels alternately up and down, but instead to arrange them in groups of ten in the order of their arrival, and then pass these groups alternately—first one group up and then the next one down. This arrangement having been made the masters of vessels were informed that a tug would notify them when their turn had come. The great majority of masters were entirely satisfied with this arrangement, and quietly awaited their turn, at the same time using their influence to preserve order. There were only a few discreditable exceptions, and these made the question of the preservation of order critical for one day only. In one case a master pushed his vessel through before his turn, and great disquiet arose amongst the others, who felt that if it was to be a scramble they must do their best to get an early passage. For a short time it seemed as though all control would be lost and discipline destroyed. But when it was made known that the offending vessel had gained nothing, but would be held at the canal until her turn came, in accordance with the time of her arrival at the obstruction, all signs of dissatisfaction disappeared.

The narrow and curved channel around the bow of the wreck and the rapid current made it advisable to use tugs in passing large boats, lest further accidents should happen, and it was mainly due to this precaution that none of any consequence occurred. The operation was necessarily a slow one, and it was not until noon of the 21st that the last waiting vessel had passed. Mr. Lynch and his assistants remained until the 22d.

The name of each vessel delayed was recorded, together with the length of time delayed, the registered tonnage, and value of each.

The total time of delay was not as accurately determined as in the case of canal records, because the time of arrival of many of the vessels below the wreck was not noted until after they had been stopped for as much as three days, and then it was obtained from their masters and depended upon their recollection. There were no large errors, however, and the results are believed to be quite trustworthy.

The statistics have been tabulated in a manner similar to those relating to the interruption of navigation by the breaking of a lock valve in 1890. The tables are long and are therefore not given in detail, but the details can be supplied if desired. The following is a summary of the information derived from them:

Number of vessels delayed	275
Valuation of same	$23,294,000
Time of delay	827 days 5 hours and 12 minutes.

In my annual report for 1890 I estimated the loss caused by the breaking of the lock valve at $56,000. The value of the delayed fleet at that time was $16,489,000 and the total time lost by delayed vessels

was 447 days 12 hours 41 minutes. If it be assumed that the loss in the present case was proportional to the time and value, then the loss caused by this accident may be estimated at $146,236.

DREDGING OPERATIONS.

Assistant Engineers E. S. Wheeler and Joseph Ripley and Mr. Sullivan, of the dredging firm of Dunbar & Sullivan, reached the site of the wreck at 8 a. m. on the morning of Sunday, October 11, in advance of the dredges. An examination of the situation showed that a channel could be most easily made around the bow of the sunken vessel, that is, to the eastward of the natural channel. The facts leading to this conclusion, were—

First. The amount of dredging required would be considerably less than on the other side.

Second. The inclination of the bow of the vessel downstream would so deflect the current, which was quite rapid, that the drift of vessels would be away from the wreck, thus lessening the chances of further collision.

The eastern side was more likely to be the leeward at this season of the year, which would again reduce the chances of further collision.

The first two conditions were positive and could be depended upon; the third was conjectural and might or might not be realized. The accidents during the passage of the delayed vessels were trivial and surely much less important than if the dredged channel had been made around the stern of the wreck.

The material to be dredged was a sandy silt, and so soft that it was difficult to "pin up" the dredges, only two of which were provided with feet at the lower ends of their spuds. The spuds sank into the bottom so deeply that some hoisting tackle was broken. Mr. Sullivan devoted all his time, day and night, to the work, and brought to it the advantage of his great energy and experience. With the Dunbar & Sullivan dredging plant from Middle Neebish, he brought their floating machine shop and boarding house, all their blacksmiths and machinists, and men from their steam drills, and so pushed the work night and day that in spite of many unexpected difficulties the channel was completed and the dredges hauled out at 3 p. m. on Thursday, the 15th. They were kept at hand, however, until noon of Friday, the 16th, for fear that additional work might be necessary, but by that time some of the largest, heaviest, and deepest-draft vessels had passed, showing that the channel would answer.

The channel dredged was about 70 feet wide at the bow of the wreck and extended up and down the stream about 300 feet in each direction. The material removed is estimated at about 12,000 cubic yards. This does not seem like a very large amount for four such dredges as those employed, backed by the other plant enumerated above, to excavate in four days; but, in view of the difficulties to be overcome, especially the softness of the bottom, I regard it as very good work and think that the progress made was largely due to the personal interest taken in it by Mr. Sullivan.

The direct expense incurred by the United States on account of the blockade was as follows:

For 495 hours of dredges, at $12 per hour	$5,940
For 8 days tug *Gossoon*, at $25 per day	200
For 9 days tug *Virginia*, at $35 per day	315
Total	6,455

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The prices charged for the dredges and tugs, as stated above, include all other private plant and all supplies therefor.

In addition to the sum of $6,455 there was an indirect cost to the Government, due to the use of the United States tug *Myra*, but it is not thought necessary to estimate it.

It may be asked why we dredged a channel around the wreck when it could have been entirely removed in as short a time. The answer is simple enough. The laws of the United States require thirty days' notice before any of their agents can proceed to remove a wreck. This statutory provision was quite sufficient to prevent any attempt in that direction and limit us to the only course left to our discretion.

The insurance companies and others interested in the wreck were not so restricted, however; yet it was five days after the collision before their wrecking outfit reached the ground, and it was not until nine days later, or fourteen days after the accident, that the wreck was swung around so as to partially clear the channel. In this position it remained for some days longer, causing more or less annoyance to passing vessels, and, again, on one occasion, for half a day completely blockading the lower entrance to the channel.

Finally, great credit is due to vesselmen for the patience and forbearance displayed during a period which must have severely tried them. Only three instances have come to my knowledge of violation of the arrangement made for the orderly passage of the vessels, and of these one was due to pure selfishness, one appears to have resulted from a misunderstanding; and another from an attempt upon the part of a master to obey a telegraphic order from the owner of the boat. In the first case, the offending vessel, being upward bound, was stopped at the canal and detained there thirty-six hours by the canal authorities until her turn came exactly in accordance with the time when she should have passed the obstruction. In this case there was no mitigating circumstance. The second vessel would also have been stopped at the canal, but she had passed through before notice was received. The master of the third appeared determined to disregard the arrangement which had been made to secure orderly passage, and paid no attention to Mr. Wheeler's directions, who then called upon the vessel captains for support, and to the number of 25 they accompanied him on a tug to a short but decisive interview with the offender. After this there was no further trouble.

In closing this report I take occasion to again invite attention to the valuable services of Mr. Martin Lynch, superintendent of St. Marys Falls Canal, who possesses in a high degree the confidence of the vesselmen.

To Mr. Sullivan, who so freely gave his time and experience to the work and with tireless energy pushed it ahead when he might, without impropriety, have left it to his employés, I desire to express my thanks.

Assistant Engineer E. S. Wheeler acted with his usual judgment and conducted the operations to my entire satisfaction.

Some criticism has been indulged in by persons who were themselves to blame for some of the bad features of the matter. I can only think that they hoped by this course to divert attention from their own delinquencies.

For the part taken by the representatives of the Government I have only commendation, and, after the event, with all the light we now have, I am unable to see where they could have done better.

The loss and annoyance to shipping interests were great, but the accident occurred at a point where no improvement has ever been made by the Government. The depth of water was ample and the width of

the channel greater than in the improved portions just above and below. It all resolves to this, that, unless navigators exercise the utmost care and are willing to yield something to each other, such accidents must be expected and are sure to come. They happen frequently, but the special attention of the public is given to them only when the effects are so far-reaching and so costly as in this instance.

Very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers, etc., Bvt. Brig. Gen., U. S. Army.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

L L 2.

OPERATING AND CARE OF ST. MARYS FALLS CANAL, MICHIGAN.

St. Mary's Falls Canal, about 1 mile in length, forms part of the water route between Lakes Huron and Superior and affords a means of passing the Sault de Ste. Marie, overcoming by its lockage system a difference of level of about 18 feet. The prism of the canal is of variable width, and has a depth of 16 feet at ordinary stages of water.

The original canal was constructed by the State of Michigan and was opened for traffic in 1855. In 1870 the United States began to enlarge the canal and to build a new and larger lock abreast of the lock of 1855. This work was completed in 1881 and the entire canal passed into the control of the General Government.

In 1887 the locks of 1855 were rendered unavailable for further service by the construction of a cofferdam to inclose the site of a new lock which was projected to replace them. This new lock is to be 800 feet long between gates, 100 feet wide throughout, with 21 feet of water on the miter sills, and is to have a single lift of about 18 feet.

The lock of 1881, upon which the entire traffic of Lake Superior now depends, is 515 feet long between gates, 80 feet wide in the chamber, narrowing to 60 feet at the gates, with 17 feet of water on the miter sills, and overcomes the difference of level by a single lift of about 18 feet. Until the proposed 800-foot lock is finished, an accident to this lock would cripple the entire commerce of Lake Superior.

CONTRACTS.

List of contracts in force during fiscal year ending June 30, 1892.

Contractor.	For—	Entered into.	Remarks.
Emery D. Weimer	Pine timber, etc	Mar. 7, 1891	Closed July, 1891.
Thomas R. Forsyth	White oak timber	do	Closed Sept., 1891.
George Kemp	Coal	do	Closed Dec., 1891.
James Strachan	Oil tank, etc	do	Closed Nov., 1891.
Do	Machine work	do	Closed Dec., 1891.
Russell Wheel and Foundry Co.	Four valve frames	Mar. 11, 1891	Closed Sept., 1891.
P. M. Church & Co	Hardware	Mar. 25, 1892	In force.
R. G. Ferguson & Co	Ship chandlery	do	Do.
P. M. Church & Co	Paints, oils, etc	do	Do.
Chas. Hebard & Son	Lumber	do	Do.
P. M. Church & Co	Electric-light supplies	do	Do.
George Kemp	Coal	do	Do.
James Strachan	Machine work	do	Do.

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ORGANIZATION.

The organization remains practically the same as last season, only a few changes having been made among the lockmen. The regular force consists of 1 superintendent, 3 assistant superintendents, 1 clerk, 3 foremen, 3 enginemen, 7 watchmen, and 27 lockmen, a total of 45. A small labor party averaging 10 men, during the working season, has been employed in making current repairs to buildings and piers and in care of grounds. The regular force is divided into three watches of 8 hours each, and this arrangement has proved very satisfactory.

ACCIDENTS AND DELAYS.

Three men have lost their lives in the canal during the year: July 5, 1891, a man by the name of Malcolm McDonald was found drowned in the canal above the locks. April 24, 1892, a sailor was drowned near the head of the canal. April 30, a sailor was crushed against the pier by the steamer *Pasadena* and instantly killed.

The low water in the canal has caused an unusual amount of grounding on the platforms. On this account the lock has been delayed on an average of one-half a day per month during the season of navigation. April 26, an elbow was broken in the pipe connecting with the engine of the north emptying valve, and in order to repair it it was necessary to pump the lock out; this was done and the pipe repaired, making a total delay of twenty-five hours and thirty-six minutes. In addition there have been the usual number of small delays caused by obstructions against the miter sill, foul tow lines, jamming of boats in the lock, etc. On the 26th of May the *S. R. Kirby* (bound down) in passing out of the locks appeared to ground on the inner platform. When her headway was nearly stopped her stern rose about 12 inches and then settled back again, and she passed on without any further difficulty. Large splinters from the platform came up. A diver was immediately sent down to determine the cause. A piece of iron 2 inches thick, 2½ feet long, and 14 inches wide was found embedded in the platform so firmly that it was necessary to saw a number of the timbers before it could be pulled out. This iron was evidently broken off the shoe of the *Kirby*. This incident, though only causing a delay of one hour and forty-five minutes, shows the importance of the platform, for without it the miter sill would undoubtedly have been carried away and the lock disabled until a new sill could have been put in.

STAGE OF WATER.

The water in the lock during the season has averaged lower than ever known before. On account of this lower stage it has been impossible for large vessels to load to their full capacity; for this reason, light-draft boats have been returned to this route, and the apparent falling off of the registered tonnage of boats using the canal is probably due to this cause.

On September 16 and 17 there were unusual fluctuations, the water rising and falling 3.65 feet in two hours.

The mean elevation of the surface of the water below the lock for the month of April was 581.79 feet above mean tide at New York, which is $\frac{8}{10}$ of a foot lower than ever before during the season of navigation.

MOVABLE DAM.

The movable dam has been tested monthly and kept in perfect order. It was closed for the winter on the 30th of December. The wickets were

sheathed with inch boards in the same manner as last season. The water was allowed to run through the inlet pipe, as is usually done, to prevent the forming of ice in the pipes; this kept the surface of the water below the dam one-half foot lower than above, thus keeping the movable dam constantly pressed against the abutments. It was taken out April 17 and the sheathing removed from the wickets.

REPAIRS.

Under contract with the Russel Wheel and Foundry Company, dated March 11, 1891, the four new steel valve frames, which were under construction at the beginning of the fiscal year, were completed and delivered at the canal in September, 1891, and the contract closed. During December and January, after the close of navigation, these frames were put in place of the cast-iron frames formerly used. Being of wrought steel and upon a plan altogether different from the old ones, they are very much stronger and better. At the same time the valve engines were provided with new piston rods.

After the close of navigation the platforms which protect the miter sills were found very much worn. The pine timbers of which they were composed were removed and replaced with oak. The north leaf of the lower lock gate was lifted up so that an examination and drawing might be made of the pivot at the bottom. Some of the boats belonging to the Government were drydocked in the lock at the same time and were thoroughly overhauled and repaired. New floors have been laid in the machine house and about 762 linear feet of superstructure have been built on the south pier above the lock.

PUMPING PLANT.

The new steam pumps which were procured last year have been put in working order. For this purpose a float has been built of the following dimensions: Length, 59 feet; breadth, 21 feet; depth, 6 feet. The two 12-inch pumps with 100-horse power engines have been placed on this float with one marine boiler having a capacity of 110-horse power; a second and similar boiler has been placed on the pier below the lock and can be connected with the pumps by steam pipes carried along the pier. These pumps have been used once. This occurred April 27, when the lock was pumped out for the purpose of repairing the broken pipe. The pumps were started at 7:26 p. m. and the lock completely pumped out at 3:35 a. m., making eight hours and nineteen minutes.

The leakage through the guard gates was very large, as no attempt was made to calk them. While the three pumps worked together, the water was lowered at an average rate of 2½ feet per hour. After the stationary pump was stopped the average made by the steam pumps alone was about 16 inches per hour. The boiler developed a good many small leaks and does not seem to be a very good one, but the engine and pumps worked admirably.

CANAL POST OFFICE.

The mail matter of people using the canal has been received and delivered as usual by the watchmen. Mail is received and delivered at all times of day or night. The total mail handled during the year is as follows: Letters, 54,643; papers and packages, 5,492; letters returned, 563; letters redirected 969.

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ESTIMATES.

The project for operating and care of the canal for the fiscal year ending June 30, 1893, contemplates maintaining the present organization, purchasing the requisite supplies, moving any buildings belonging to the canal that may stand in the way of the work in progress in connection with the construction of the proposed new lock, possibly constructing a new set of lower gates for the existing lock (of 1881), purchasing the timber necessary for repairing canal piers, adding two stories to the present machine house, and employing such labor as may be required in making current repairs and policing the grounds.

The estimated cost of the foregoing is as follows:

Pay of regular lock force	$30,000
Pay of labor party	6,000
General purchases	5,000
Repairs and additions to machine house	10,000
Timber for repairing canal piers, etc	4,000
Additional electric-light plant	4,000
Total	59,000

No estimate is included for extraordinary repairs which may be rendered necessary by accident. Such can not be foreseen, and, therefore, can not be estimated for.

In case of injury or damage to the canal beyond that due to ordinary wear and tear, it must be promptly made good at whatever cost.

All expenses of operating and care are provided for by indefinite appropriation, under section 4 of the river and harbor act approved July 5, 1884.

Total expenditure to June 30, 1891		$316,015.34
Expended during fiscal year, exclusive of liabilities outstanding June 30, 1892		57,870.99
Total expenditure to June 30, 1892		373,886.33

St. Marys Falls Canal is in the collection district of Superior, Mich. The nearest port of entry is Marquette, but Sault Ste. Marie is a subport. Two beacons stand upon the piers at the western end of the canal and Fort Brady is within half a mile.

Amount required for fiscal year ending June 30, 1893		$59,000.00
Balance remaining from allotments of preceding year, exclusive of outstanding liabilities	$9,559.01	
Outstanding liabilities	4,876.53	
		4,682.48
Allotment required for fiscal year ending June 30, 1893		54,317.52

Appropriations for operating and care of St. Marys Falls Canal, Michigan.

Expended during fiscal year ending June 30—	
1882	$31,207.48
1883	35,509.70
1884	31,212.93
1885	27,242.45
1886	25,400.95
1887	22,138.92
1888	29,898.72
1889	30,749.45
1890	34,323.85
1891	48,330.89
1892	61,389.74
Total	377,405.08

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Statement of receipts and expenditures at St. Marys Falls Canal during fiscal year ending June 30, 1892.

Receipts:		
Balance at close of fiscal year ending June 30, 1891		$19,669.11
Allotted July 8, 1891		47,730.89
		67,400.00
Expenditures:		
Office expenses	$1,240.93	
General purchases	8,612.50	
Repairs	21,665.12	
Labor, operating and care	28,042.50	
Extra labor	1,828.69	
		61,389.74
Balance at close of fiscal year ending June 30, 1892		6,010.26

COMMERCE PASSING ST. MARYS FALLS CANAL, MICHIGAN, DURING THE SEASON OF 1891.

[Printed in House Ex. Doc. No. 18, Fifty-second Congress, first session.]

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., December 16, 1891.

GENERAL: I have the honor to submit the following report upon the commerce passing St. Marys Falls Canal during the season of 1891, just closed. At this work statistics for the season are necessarily those of the calendar year.

The canal opened for navigation April 27, 1891, and closed December 7. The season was therefore 225 days long, or 3 days shorter than in 1890.

The average number of vessels passing per day for the whole season was 45.3, and for the months of June, July, August, and September the average was 54.6.

The size of the vessels continues to increase, as is shown in the following statistics:

The average registered tonnage per vessel was—	Tons.
In 1887	626.3
In 1888	701.5
In 1889	790.5
In 1890	833.8
In 1891	862.1

The total registered tonnage for the season falls 53,750 tons short of that for 1890, and the freight tonnage was 152,454 tons less. The following discussion of the appended statistics may not be inappropriate:

For the whole period since 1881 the iron ore carried through the canal has been 47 per cent of the total freight, and in 1889 and 1890 it was more than 50 per cent; therefore the freight may be divided into two nearly equal parts, one of which was the iron ore, the remainder being the aggregate of all other freights. The percentage of increase since 1881 falls between 12 and 39 each year, the average being 22. During 1890 the freight other than iron ore amounted to 4,266,445 tons, and for 1891 to 5,328,548 tons. This shows an increase of 25 per cent in the freight of 1891, other than iron ore, over 1890, or a little more than the average increase for the preceding ten years. Hence the decrease in iron-ore freight alone is sufficient to explain why the business of 1891 did not show the usual increase. There were other causes, however,

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which materially affected the volume of the season's business, and they will be referred to later.

The falling off in iron-ore freight was predicted with certainty a year ago. It was due to causes so widespread and long continued that a discussion here could hardly be made complete and satisfactory.

The freight of wheat and wheat products was abnormally large. Excluding iron ore and wheat in 1890 the remaining tonnage was 3,725,866 tons. The corresponding freight for 1891 was 4,340,660 tons. Hence the increase in freight, exclusive of iron ore, was 8 per cent, which indicates quite a falling off from the average rate of 22 per cent for the last ten years, and shows that if the wheat crop of the northwest had not been unusually good this season there would have been a slight decrease in the volume of freight other than iron ore.

The foregoing relates solely to tonnage. If we consider the value of the season's freight we find a very large increase over any other.

The average yearly increase in the value of the freight transported since 1881 was about 15 per cent, but for the season of 1891 it was about 25 per cent. The cause of this great increase in valuation is plainly due to the very large wheat crop. Since we are not likely to be immediately favored with another such crop, a decrease in valuation may be reasonably predicted for next year.

But the failure to maintain the record of annual increase in freight tonnage is due, in a great degree, to three causes other than the decrease in iron-ore tonnage.

The first of these is the fact that the stage of water in the lakes, and consequently the depth available at the canal, was the lowest of which we have any record. In 1889 the average available depth was 15.14 feet, in 1890 it was 15.06 feet, and in 1891 it was 14.42 feet. The average for 1891 was, therefore, 0.64 foot, or 7.6 inches lower than in 1890, which, at a reasonable estimate of 20 tons to an inch of draft, corresponds to an average of, say, 150 tons for each registered vessel; that is, if the available depth of water in the canal during 1891 had been equal to that of 1890 (the next lowest recorded), the same 9,744 vessels which carried 8,888,759 tons in 1891, would have carried 1,461,359 tons more than they did, or an aggregate of 10,350,359 tons, or, say, 10,000,000. This is no violent estimate, but is, I think, quite within the truth.

The next cause was the intentional delay of the vessel men in putting their vessels in commission in the spring. This amounted to quite two weeks in the case of many of the largest carriers. No attempt is made to estimate the effect of the delay, but it must have been considerable.

The third cause was due to the sinking of the steamer *Susan E. Peck*, at "the Elbow," in St. Marys River, by which navigation was totally suspended from 1:10 p. m., October 11, to 3 p. m., October 15, a period of full five days. Two hundred and seventy-five vessels were delayed an aggregate of eight hundred and twenty-seven days five hours, or an average of about three days each, during which time they would have carried through the canal about 150,000 tons of freight if they had been free to move. This fairly offsets the delay during the preceding season due to the broken emptying valve.

In view of the foregoing, it would be a conservative estimate to say that but for the conditions stated the freight through the canal would have amounted to 10,500,000 tons during the season of 1891.

In estimating the value of the commerce passing through the canal it is deemed advisable to adhere to the same prices per unit first adopted in 1885. It is believed that these constitute a fair average and

afford a better basis for comparing the business from year to year than if they were amended to conform to the prices actually prevailing.

Very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers, etc.,
Brevet Brigadier-General, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Comparative statement of the amount and value of commerce through St. Marys Falls Canal, Michigan, for the calendar years 1890 and 1891.

Items.	Quantity.		Increase.		Decrease.	
	1890.	1891.	Amount.	Per cent.	Amount.	Per cent.
Vessels* ..... number..	10,557	10,191			366	3
Lockages ..... do....	4,970	4,981	11	0		
Tonnage, registered ..... net tons..	8,454,435	8,400,685			53,750	1
Tonnage, freight ..... do....	9,041,213	8,888,759			152,454	2
Passengers ..... number..	24,856	26,190	1,334	5		
Coal (hard and soft) ..... net tons..	2,176,925	2,507,532	330,607	18		
Flour ..... barrels..	3,239,104	3,780,143	541,039	17		
Wheat ..... bushels..	16,217,370	38,816,570	22,599,200	139		
Grain (other than wheat) ..... do....	2,044,384	1,032,104			1,012,280	50
Manufactured iron ..... net tons..	93,615	42,560			51,055	55
Pig iron ..... do....	22,712	27,181	4,469	19		
Salt ..... barrels..	179,431	234,528	55,097	31		
Copper ..... net tons..	43,729	69,190	25,461	58		
Iron ore ..... do....	4,774,768	3,560,213			1,214,555	25
Lumber ..... M ft., B. M..	361,929	366,305	4,376	1		
Silver ore and bullion ..... net tons..	3,432	1,731			1,701	50
Building stone ..... do....	47,973	44,080			3,893	8
Unclassified freight† ..... do....	371,294	417,093	45,799	12		

Items.	Total valuation.		
	Price per unit.	1890.	1891.
Vessels* ..... number..			
Lockages ..... do....			
Tonnage, registered ..... net tons..			
Tonnage, freight ..... do....			
Passengers ..... number..			
Coal (hard and soft) ..... net tons..	$3.50	$7,619,237.50	$8,776,362.00
Flour ..... barrels..	5.00	16,195,520.00	18,900,715.00
Wheat ..... bushels..	.98	15,893,022.60	38,040,238.60
Grain (other than wheat) ..... do....	.98	2,003,496.32	1,011,461.92
Manufactured iron ..... net tons..	50.00	4,680,750.00	2,128,000.00
Pig iron ..... do....	17.00	386,104.00	462,077.00
Salt ..... barrels..	1.00	179,431.00	234,528.00
Copper ..... net tons..	200.00	8,745,800.00	13,838,000.00
Iron ore ..... do....	3.50	16,711,688.00	12,460,745.50
Lumber ..... M ft., B. M..	18.00	6,514,722.00	6,593,490.00
Silver ore and bullion ..... net tons..	153.79	527,807.28	266,210.49
Building stone ..... do....	10.00	479,730.00	440,800.00
Unclassified freight† ..... do....	60.00	22,277,640.00	25,025,580.00
Totals		102,214,948.70	128,178,208.51

*Steamers	7,339
Sails	2,405
Unregistered craft	447
Total	10,191

† Included in unclassified freight for 1891—

Wool	tons.	2,602
Hides	do....	400

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Valuation based on estimates of 1885.

Valuation for—	
1885	$53,413,472.13
1886	69,080,071.95
1887	79,031,757.78
1888	82,156,019.97
1889	83,732,527.15
1890	102,214,948.70
1891	128,178,208.51

Canal was open to navigation during season of 1890, 228 days; 1891, 225 days.

COMMERCIAL STATISTICS.

Comparative statement of traffic through St. Marys Falls Canal for fiscal years ending June 30, 1891, and June 30, 1892.

Items.	Fiscal years.		Increase.		Decrease.	
	1891.	1892.	Amount.	Per cent.	Amount.	Per cent.
Vessels ... numbers	9,541	11,557	2,016	21		
Lockages ... do	4,614	5,615	1,001	22		
Tonnage:						
Registered ... net tons	7,431 423	9,828,874	2,397,451	32		
Freight ... do	8,338,981	10,107,603	1,768,622	21		
Passengers ... number	26,226	25,697			529	2
Coal ... net tons	2,298,487	2,717,029	418,542	18		
Flour ... barrels	3,460,238	4,184,612	724,374	21		
Wheat ... bushels	18,184,989	48,466,240	30,281,251	167		
Grain (other than wheat) ... do	1,291,084	952,891			338,193	26
Manufactured and pig iron ... net tons	108,441	73,047			35,394	33
Salt ... barrels	188,292	236,169	47,877	25		
Copper ... net tons	48,816	65,667	16,851	35		
Iron ore ... do	3,873,044	4,142,797	269,753	7		
Lumber ... M feet, B. M.	383,461	399,985	16,524	4		
Silver ore ... net tons	3,076	1,330			1,746	57
Building stone ... do	45,506	38,678			6,828	15
Unclassified freight ... do	354,375	443,212	88,837	25		

Statement of the number of vessels passed through St. Marys Falls Canal, with number and cost of lockages for fiscal year ending June 30, 1892.

Number of vessels	11,557
Number of lockages	5,615
Registered tonnage	9,828,874
Freight tonnage	10,107,603

	Hrs.	Min.
Total time during which lock was operated	3,860	8
Average time occupied in making a lockage		41
Total time spent by vessels in the lock	6,833	20
Average time spent by vessels in passing lock		36

Cost, per lockage	$10.93
Cost, per vessel	$5.31
	Mills.
Cost, per registered ton	6.25
Cost, per freight ton	6.07

NOTE.—Cost includes all repairs and improvements made by the operating and care force and labor party, and purchases therefor.

The total freight exceeds that of any other fiscal year by 1,768,622 tons. The total freight during the season of 1891, that is, during that calendar year, was about 2 per cent less than for the preceding season; but the traffic so far in 1892 has been so great that this deficiency is more than made up, and the traffic for the fiscal year is, as stated, very much larger than ever before.

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DISCUSSION OF TRAFFIC THROUGH ST. MARYS FALLS CANAL DURING CALENDAR YEAR 1891.

This discussion was made by Clerk Andrew Jackson, and is similar to those submitted each year since 1887. The prime object has been to obtain the cost of carrying a ton of freight 1 mile; taking as a basis the entire traffic to and from Lake Superior which has passed the canal and reported in proper form to the canal authorities.

The method used to obtain this result is precisely like those used in previous years, which have been given in all former reports, in minute detail.

The results have been carefully compared and checked and, I believe, are as nearly correct as they can be made from the data in possession of this office, connected with that necessarily obtained from outside sources. Quite a disappointment was experienced in the failure of shippers, owners, and managers to reply as generally to our letters requesting freight rates for the different articles of commerce as they did last season. A comparison of the tables, however, for 1890 and 1891 is sufficient proof that the information furnished for the latter year, although only having been reported by twenty-one different parties, is fully as complete and reliable as that of the thirty-three furnishing information for the previous season.

The data thus obtained is shown in the following table; the mean having been derived from a general discussion of the rates given in answer to our requests, by a separate examination and report by Assistant Engineer E. S. Wheeler, Clerk Andrew Jackson, and Watchman McMahon, the variation in the conclusions reached being so small as to leave little doubt as to the correctness of the average.

The mean thus adopted, which is shown on the bottom line of the table, is as follows:

Miscellaneous merchandise, $3.58 per ton; coal, 43 cents per ton; flour, 15 cents per barrel; wheat, 4.6 cents per bushel; grain (other than wheat), 3½ cents per bushel; manufactured iron, $2.50 per ton; pig iron, $1.17 per ton; salt, 18 cents per barrel; copper $2 per ton; iron ore, 98 cents per ton; lumber, $2.70 per M feet, B. M.; silver ore and bullion, $2.25 per ton, and building stone, $2 per ton.

After the average rate had been adopted, a table was formed from which was obtained the total amount paid for the transportation of freight which passed the canal during the season of 1891, amounting to $9,849,022.81.

Freight rates on articles of commerce for the season of 1891.

Unclassified freight, net tons.	Coal, net ton.	Flour, barrel.	Wheat, bushel.	Grain, bushel.	Manufactured iron, net ton.	Pig iron, net ton.	Salt, barrel.	Copper, net ton.	Iron ore, net ton.	Lumber, M ft. B. M.	Silver ore, etc., net ton.	Building stone, net ton.
	Cts.	*Cts.*	*Cts.*	*Cts.*			*Cts.*					
$2.45	38	13	2¾		$2.25		18	$2.25			$2.25	
	50		2¼									
			4½						$0.90			
										$1.75		
	47 3/10		4 3/10						83½	3.10		
	36½		4½	4½					1.15			
	55					$0.90			1.11½			
	45		5		1.07							
	69											
	28¾		4¾						97½	2.50		
	34¾	14 3/10	3	2 1/10				1.80				
4.00		25	3	3	3.00	1.33	18	1.80				
	45								95			
3.78	25		7	4¼						2.50		
									1.12½	2.25		
	45		9¾						1.00			
									98			
	47¾		4 1/10						86¾			
	39½		5½						88½	2.83		
	44 1/10		7 3/10									
	45		3¾						1.03¾			
									96¾			
3.58	43	15	4 6/10	3½	2.50	1.17	18	2.00	98	2.70	2.25	2.00
Adopted means.												

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Mile tons, season of 1891. Cost of carrying freight transported through St. Marys Falls Canal.

Items.	Unit.	Quantity.	Price per unit.	Amount.
Coal	Net tons	2,507,532	$0.43	$1,078,238.76
Flour	Barrels	3,780,143	.15	567,021.45
Wheat	Bushels	38,816,570	.04	1,785,562.22
Grain, other than wheat	do	1,032,104	.03	36,123.64
Manufactured iron	Net tons	42,560	2.50	106,400.00
Pig iron	do	27,181	1.17	31,801.77
Salt	Barrels	234,528	.18	42,215.04
Copper	Net tons	69,190	2.00	138,380.00
Iron ore	do	3,560,213	.98	3,489,008.74
Lumber	M feet	366,305	2.70	989,023.50
Silver ore and bullion	Net tons	1,731	2.25	3,894.75
Building stone	do	44,080	2.00	88,160.00
Miscellaneous merchandise	do	417,093	3.58	1,493,192.94
Total				9,849,022.81

NOTE.—In this table "tons" means net tons, or tons of 2,000 pounds.

The total amount of freight paid, $9,849,022.81, divided by the total mile tons, 7,292,462,269, gives the cost per mile ton as 1.35 mills.

The average distance freight was carried was 820.4 miles, which was 23.2 miles greater than in 1890.

The nature of the data from which the preceding result was found is such that it includes the cost of loading and unloading.

The results obtained were as follows:

Total mile tons		7,292,462,269
Total freight paid		$9,849,022.81
Cost per mile ton	mills	1.35
Average distance freight was carried	miles	820.4

The total number of registered craft which used the canal during the season was—

Steamers	396
Sail vessels	256
Total	652

American craft.

Class.	No.	Registered tonnage.	Freight tonnage.	Number of passengers.	Valuation.
Steamers	358	325,697	6,129,521	13,817	$26,879,100
Sails	237	142,667	2,396,557	.....	5,068,200
Total	595	468,364	8,526,078	13,817	31,947,300

NOTE.—Eleven thousand seven hundred and twenty-nine net tons of freight were also carried by American unregistered craft in 447 passages, the average cargo being $26\frac{1}{10}$ tons.

Canadian craft.

Class.	No.	Registered tonnage.	Freight tonnage.	Number of passengers.	Valuation.
Steamers	38	18,489	291,418	12,373	$1,771,500
Sails	19	8,255	59,534	.....	348,000
Total	57	26,744	350,952	12,373	2,119,500

Summary.

Total number of registered craft		652
Total passages by unregistered craft		447
Total freight carried by registered craft	tons	8,877,030
Total freight carried by unregistered craft	do	11,729
Total passengers carried		26,190
Valuation of craft (registered)		$34,066,800

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The total passages for the season amounted to 10,191; 1,696 of these were by 67 craft of under 100 tons register. Their aggregate registered tonnage was 1,960 tons and their average tonnage 29$\frac{17}{67}$ tons. The freight carried during the season by these craft only amounted to 1,724 tons.

From the column of "largest cargoes" it is ascertained that there were 101 steamers that carried in their greatest loads 2,000 tons and upwards; that these 101 cargoes aggregated 227,236 tons and averaged 2,249 tons. There were 18 steamers that carried 2,500 tons and upwards, aggregating 47,200 tons and averaging 2,622 tons. Two sail vessels carried 2,000 tons and upwards, aggregating 52,084 tons and averaging 2,367 tons. Eight sail vessels carried 2,500 tons and upwards, aggregating 21,539 tons and averaging 2,692 tons.

The greatest number of miles run during the season was 43,107 by the American propeller *Mariska*, of the Minnesota Steamship Line. The greatest amount of freight carried during the season is to the credit of the propeller *Castalia*, of Cleveland, Ohio, aggregating 68,943 tons.

The greatest number of mile tons for the season is to the credit of the propeller *Northern Queen*, of Buffalo, N. Y., and is 60,899,000. This boat also earned the same credit last season, having carried 68,794,994. The largest single cargo carried by any vessel is to the credit of the American propeller *E. C. Pope*, and amounted to 3,136 tons.

The largest single cargo carried by a sail vessel is to the credit of the American Steel Barge Company's tow barge *No. 111*, and amounted to 2,950 tons.

A discussion of the watchmens' record for the season of 1891 shows the total time spent by boats in the canal to be 1,816 days, 13 hours, and 19 minutes. This does not include the time of the harbor tugs nor the tugs and scows used by the contractors doing work on the 800-foot lock.

The total number of passages (including the above-mentioned craft) is 8,650. Dividing the time by the number of passages gives 5 hours and 25 minutes, which is the average time spent by boats in passing the canal during the season of 1891. A further discussion of the watchmen's records shows that boats remained in the canal for their own convenience a total of 614 days and 19 hours. Subtracting this time from the former and dividing by the total passages gives 3 hours and 20 minutes as the average time necessarily spent in passing the canal during the season of 1891. The watchmen's record also shows that the railroad bridge was closed during the season of 1891 14 days 15 hours and 45 minutes; during the same period the bridge was delayed by boats 5 hours and 54 minutes and boats were delayed by the bridge 1 hour and 58 minutes.

Abstract of bids for supplies for operating and care of St. Marys Falls Canal, Michigan, received and approved March 14, 1892, in accordance with advertisement dated February 23, 1892.

No.	Name and address of bidder.	Supplies.	Total.
1	P. M. Church & Co., Sault Ste. Marie, Mich	Hardware	*$313.97
2	R. G. Ferguson & Co., Sault Ste. Marie, Mich	do	323.08
3	Hodgson & Howard, Detroit, Mich	do	333.90
4	T. B. Rayl & Co., Detroit, Mich	do	†360.02
1	R. G. Ferguson & Co., Sault Ste. Marie, Mich	Ship chandlery	*539.72
2	P. M. Church & Co., Sault Ste. Marie, Mich	do	632.50
1	P. M. Church & Co., Sault Ste. Marie, Mich	Paints, oils, etc	*374.64
2	R. G. Ferguson & Co., Sault Ste. Marie, Mich	do	380.70
3	Greeslade Oil Co., Detroit, Mich	do	421.73
4	Williams, Davis, Brooks & Co., Detroit, Mich	do	439.73
5	Farrand, Williams & Clark, Detroit, Mich	do	445.18
1	Chas. Hebard & Son, Sault Ste. Marie, Mich	Lumber	*1,057.50
2	Emory D. Weimer, Ludington, Mich	do	1,440.70
1	P. M. Church & Co., Sault Ste. Marie, Mich	Electric light supplies	*148.20
2	R. G. Ferguson & Co., Sault Ste. Marie, Mich	do	185.00
3	The Electrical Equipment Co., Detroit, Mich	do	492.25
1	George Kemp, Sault Ste. Marie, Mich	Coal	*500.50
2	Thomas C. Anthony, Sault Ste. Marie, Mich	do	563.00

No.	Name and address of bidder.	Machine work, 100 hours, per hour.					
		Lathe.	Planer.	Steam hammer.	Bolt cutter.	Power drill.	Total.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	
1	James Strachan, Sault Ste. Marie, Mich.	*40	30	70	30	30	$200

* Recommended for acceptance. † Incomplete; no bid on stops.

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Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, indefinite, applied to operating and care of St. Marys Falls Canal, Michigan, for the fiscal year ending June 30, 1892.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Part of first quarter, 1892.		
1891. July 24	3	Morris Machine Works, per William F. Morris, sole owner and proprietor.	For furnishing and delivering at St. Marys Falls Canal, Michigan, 2 No. 12 centrifugal pumps with engines, boilers, boiler feed pumps, foot valves, flap valves, ejectors, elbows, pipe, gaskets, bolts, etc., complete for an agreed price of.	$7,905.00
18	4	Emery D. Weimer	Furnishing and delivering at St. Marys Falls Canal, Michigan—	
			106 cedar fence posts, at 20 cents each.	21.20
			102 pieces round white oak timber 8 feet long, 16 inches in diameter at one end, at $4.45 each.	453.90
18	5	Emery D. Weimer	Furnishing and delivering at St. Marys Falls Canal, Michigan—	
			10,000 shingles, at $2.50 per M	25.00
			10,200 feet, B. M., pine lumber, common stock, 1 inch by 12 inches by 16 feet, at $16.75 per M.	170.85
			1,045 feet, B. M., pine lumber, common stock, 2 inches by 14 inches by 16 feet, at $14.50 per M.	15.15
			6,112 feet, B. M., pine lumber, common stock, 2 inches by 12 inches by 16 feet, at $16.50 per M.	100.85
			4,116 feet, B. M., pine lumber, common stock, 4 inches by 4 inches by 16 feet, at $15.50 per M.	63.80
			72,284 feet, B. M., square timber, 12 inches by 12 inches by 16 feet, at $18.25 per M.	1,319.18
			269,376 feet, B. M., square timber, 12 inches by 12 inches by 24 feet and upwards, at $21 per M.	5,656.90
27-28	6	O. M. Poe, Colonel Corps of Engineers, etc.	Mileage from Detroit, Mich., to Grand Rapids, Mich., and return, being 316 miles, at 8 cents per mile.	25.28
31	7	Frank M. Dunlap	Services as draftsman from July 1 to July 31, 1891 (both days inclusive), being one month.	125.00
Aug. 3	8, 9	Pay rolls, July, 1891	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00
			3 lockmen, 2 months and 28½ days, at $60 per month.	177.00
			3 lockmen, 2 months and 21 days, at $50 per month.	185.00
			21 lockmen, 20 months and 28 days, at $45 per month.	942.00
			10 laborers, 9 months and 27½ days, at $45 per month.	446.25
			2 divers, 10½ days, at $7.50 per day	78.75
			1 scrubber, 10 days, at $1.20 per day	12.00
			1 carpenter, 25½ days, at $2.50 per day	63.00
			1 tinner, 14 7/12 days, at $3 per day	43.75
			1 machinist, 8 1/10 days, at $3 per day	24.15
Aug. 4	10	John Hickler & Son	One kitchen sink with waste pipe and fixtures.	9.30
Aug. 31	11	Frank M. Dunlap	Services as draftsman, from August 1 to August 31, 1891 (both days inclusive), being 1 month.	125.00
Sept. 3	12, 13	Pay rolls, August, 1891	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00

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Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, etc.—Continued.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Part of first quarter, 1892—Continued.		
1891. Sept. 3	12, 13	Pay rolls, August, 1891	3 watchmen, 2 months and 22 days, at $50 per month.	$136.67
			2 watchmen, at $45 per month	90.00
			3 lockmen, at $60 per month	180.00
			3 lockmen, 2 months and 19 days, at $50 per month.	131.67
			20 lockmen, 18 months, and 6 days, at $45 per month.	819.00
			10 laborers, 9 months and 24 days, at $45 per month.	441.00
			1 diver, 10 days, at $7.50 per day	75.00
			1 carpenter, 25 days, at $2.50 per day	62.50
			1 scrubber, 12½ days, at $1.20 per day	15.00
			1 locksmith, 1½ days, at $2 per day	2.50
2	14	Thomas R. Forsyth	Furnishing and delivering at Sault Ste. Marie, Mich., 10,402 feet, B. M., white oak timber, at $80 per M feet, B. M.	832.16
3	15	C. W. Farr, proprietor	Rent of telephone, 3 months, from June 1 to August 31, 1891 (both dates inclusive), at $48 per year.	12.00
17	16	Russel Wheel and Foundry Company, by George H. Russel, president.	Constructing and delivering at St. Marys Falls Canal, Michigan, four (4) valve frames for the sum of.	4,367.30
30	17	Justin E. Smith	Rent of 1 storage room at Detroit, Mich., from July 1 to September 30, 1891 (both days inclusive), being 3 months, at $10 per month.	30.00
30	18	Frank M. Dunlap	Services as draftsman from September 1 to September 30, 1891 (both days inclusive), being 1 month.	125.00
		Second quarter, 1892.		
Oct. 3	1, 2	Pay rolls, September, 1891	1 superintendent	150.00
			3 assistant superintendents, 2 months and 20 days, at $100 per month.	266.67
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00
			3 lockmen, 2 months and 29½ days, at $60 per month.	179.00
			3 lockmen, 2 months and 29½ days, at $50 per month.	149.17
			21 lockmen, 20 months and 25 days, at $45 per month.	937.50
			9 laborers, 8 months and 12½ days, at $45 per month.	378.37
			2 divers, 1 day	7.50
			1 scrubber, 10 days, at $1.20 per day	12.00
			1 tinner, 4½ days, at $3 per day	14.40
			2 machinists, 28½ days, at $3 per day	84.75
			1 carpenter, 26 days, at $2.50 per day	65.00
June 9	3	Board of Public Works, by F. M. Taylor, deputy secretary.	One ¾-inch tap from city water-main to curbstone.	10.00
Oct. 1			Water-rent from July 1 to September 30, 1891 (both dates inclusive), at $9 per year.	2.25
31	4	Frank M. Dunlap	Services as draftsman from October 1 to October 31, 1891 (both days inclusive), being one month.	125.00
Nov. 3	5, 6	Pay rolls, October, 1891	1 superintendent	150.00
			3 assistant superintendents, at $100 per month	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, 3 months and 27 days, at $75 per month.	292.50
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00

Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, etc.—Continued.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Second quarter, 1892—Cont'd.		
1891. Nov. 3	6, 6	Pay rolls, October, 1891	3 lockmen, at $60 per month	$180.00
			3 lockmen, at $50 per month	150.00
			21 lockmen, 20 months and 28 days, at $45 per month.	942.00
			9 laborers, 8 months and 25 days, at $45 per month.	397.50
			1 scrubber, 12½ days, at $1.20 per day	15.00
			1 carpenter, 27 days, at $2.50 per day	67.50
			4 calkers, 37½ days, at $2.50 per day	93.75
			2 teams, 2¼ days, at $4 per day	9.00
			1 tinner, 1½ days, at $3 per day	4.50
			1 diver, 3 days, at $7.50 per day	22.50
5	7	George Kemp	5 tons anthracite coal (chestnut), at $5.60 per ton.	28.00
			45 tons anthracite coal (stove), at $5.50 per ton.	247.50
			20 tons bituminous coal (Masaillon), at $3.75 per ton.	75.00
			6 tons cannel coal (West Virginia) at $5.25 per ton.	31.50
7	8	James Strachan	1 suction pipe, 5 feet 9 inches long, 15 inches in diameter, of boiler plate ¼-inch thick, with cast-iron flanges.	38.50
			One tank, 10 feet long, 8 feet wide, and 4 feet high, of ¼-inch boiler iron.	287.00
3	9	The Richmond and Backus Company, by Charles F. Backus, secretary and treasurer.	2,000 ⅛-sheet paper, plain, unruled, at $2 per M.	4.40
16			25 sheets paper, carbon, at $4 per hundred.	1.00
Dec. 3	10, 11	Pay rolls, November, 1891	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00
			3 lockmen, at $60 per month	180.00
			3 lockmen, 2 months and 29½ days, at $50 per month.	149.17
			21 lockmen, 20 months and 29½ days, at $45 per month.	943.50
			9 laborers, 6 months and 25 days, at $45 per month.	307.50
			1 diver, ½ day, at $7.50 per day	3.75
			1 scrubber, 8¾ days, at $1.20 per day	10.50
			1 carpenter, 23½ days, at $2.50 per day	58.75
			3 caulkers, 11¼ days, at $2.50 per day	28.14
			1 tinner, 5⅓ days, at $3 per day	16.80
			1 machinist, 14 7/10 days, at $3 per day	44.10
			1 team, ½ day, at $3 per day	1.50
21–24	12	O. M. Poe, Colonel Corps of Engineers, etc.	Mileage from Detroit, Mich., to Sault Ste. Marie, Mich., and return, being 774 miles, at 8 cents per mile.	61.92
Nov. 30	13	C. W. Farr, proprietor	Rent of three (3) telephones from May 1 to November 30, 1891 (both days inclusive), at $90 for the season of navigation (or 7 months).	90.00
Dec. 31	14	Justin E. Smith	Rent of one storage room at Detroit, Mich., from October 1 to December 31, 1891 (both days inclusive), being 3 months, at $10 per month.	30.00
		Third quarter, 1892.		
1892. Jan. 5	1, 2	Pay rolls, December, 1891	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00

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Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, etc.—Continued.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Third quarter, 1892—Cont'd.		
1892. Jan. 5	1, 2	Pay rolls, December, 1891 ..	3 lockmen, 2 months and 28½ days, at $60 per month.	$177.00
			3 lockmen, 2 months and 22 days, at $50 per month.	136.67
			21 lockmen, 20 months and 25½ days, at $45 per month.	938.25
			3 laborers, 1 month and 27 days, at $45 per month.	85.50
			2 divers, 6 days, at $7.50 per day	45.00
			1 scrubber, 8¾ days, at $1.20 per day	10.50
			1 carpenter, 27 days, at $2.50 per day	67.50
			1 tinner, 21½ days, at $3 per day	63.50
			7 machinists, 164½ days, at $3 per day	493.50
			2 teams, 5¾ days, at $4 per day	23.00
1891. Dec. 31	3	C. S. Osborn, postmaster ...	Rent of post-office box No. 430 for the quarter ending Dec. 31, 1891.	1.00
31	4	C. W. Farr, proprietor	Rent of telephone, 4 months from Sept. 1 to Dec. 31, 1891 (both dates inclusive), at $48 per year.	16.00
31	5	Board of Public Works, by F. M. Taylor, deputy recorder.	Water rent for the fourth quarter, 1891, Oct. 1 to Dec. 31, 1891 (both dates inclusive), at $9 per year.	2.25
1892. Feb. 1	6	Pay-roll, January, 1892, office Supervising Engineer.	2 clerks, at $175 per month	350.00
			1 clerk	100.00
			1 draftsman	175.00
			1 copyist	50.00
			1 office attendant	50.00
			1 messenger	45.00
			1 scrubber	5.00
6	7 and 8	Pay-rolls, January, 1892	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, at $50 per month	150.00
			1 watchman	45.00
			3 lockmen, at $60 per month	180.00
			3 lockmen, at $50 per month	150.00
			21 lockmen, 13 months and 1½ days, at $45 per month.	611.25
			1 scrubber, 6¼ days, at $1.20 per day	7.50
			1 carpenter, 25 days, at $2.50 per day	62.50
			1 team, 1¾ days, at $4 per day	7.00
			1 tinner, 1¼ days, at $3 per day	3.75
			8 machinists, 147½ days, at $3 per day	441.99
			1 laborer, 3 days, at $1.50 per day	4.50
Jan. 5	9	Amos Stiles	Services as watchman during month of January, 1892, from 1st to 5th (both dates inclusive), being 5/30 of a month, at $45 per month.	7.50
Feb. 3	10	American Express Company, by R. A. Cotton, cashier, Detroit, Mich., office.	Express charges on one box, weight 14 pounds, containing samples of articles required by the United States, and to enable intending bidders to base their bids upon, from Sault Ste. Marie to Detroit, Mich.	.80
Mar. 3	11 and 12	Pay rolls, February, 1892 ...	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, 2 months and 27 days, at $75 per month.	217.50
			1 watchman	75.00
			3 watchmen, 2 months and 12 days, at $50 per month.	120.00
			1 watchman	45.00
			3 lockmen, 1 month and 27 days, at $60 per month.	114.00
			3 lockmen, 1 month and 27 days, at $50 per month.	95.01

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Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, etc.—Continued.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Third quarter, 1892—Cont'd.		
1892.				
Mar. 13	11 and 12	February, 1892	3 lockmen, 1 month and 23 days, at $45 per month.	$79.50
			1 carpenter, 17 days, at $2.50 per day	42.50
			1 scrubber, 5 days, at $1.20 per day	6.00
			1 blacksmith 18⅔ days, at $3 per day	56.40
			1 tinner, 1¼ days, at $3 per day	3.75
			4 machinists, 96 days, at $3 per day	288.00
1891.				
Apr. 4	13	James Strachan	383¾ hours' work with steam hammer, at at 70 cents per hour.	268.62
Dec. 31			11 hours' work with planer, at 35 cents per hour.	3.85
			34½ hours' work with steam-power drill, at 35 cents per hour.	12.07
			113⅓ hours' work with bolt cutter, at 35 cents per hour.	39.73
			16½ hours' lathe work, at 40 cents per hour.	6.60
30	14	James Strachan	4 sets of slides for valve engines, cast, planed, and fitted.	119.50
1892.				
Feb. 23	15	The Richmond and Backus Company, by Charles F. Backus, secretary and treasurer.	50 sheets paper, carbon, at $4 per hundred.	2.00
Mar. 31	16	Justin E. Smith	Rent of one storage room at Detroit, Mich., from January 1 to March 31, 1892 (both days inclusive), being 3 months, at $10 per month.	30.00
		Fourth quarter, 1892.		
Apr. 4	1 and 2	Pay rolls, March, 1892	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			3 watchmen, 2 months and 29½ days, at $50 per month.	149.17
			2 watchmen, 1 month and 8 days, at $45 per month.	57.00
			3 lockmen, at $60 per month	180.00
			3 lockmen, at $50 per month	150.00
			21 lockmen, 20 months and 21 days, at $45 per month.	931.50
			1 scrubber, 6¼ days, at $1.20 per day	7.50
			1 team, 2 days, at $4 per day	8.00
			1 machinist, 23⅓ days, at $3 per day	71.60
May 4	3 and 4	Pay rolls, April, 1892	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			1 watchman, ⅓ months, at $55 per month.	22.00
			4 watchmen, 3 months, at $50 per month.	150.00
			2 watchmen, 1 month and 12 days, at $45 per month.	63.00
			3 lockmen, 2 months and 25½ days, at $60 per month.	171.00
			3 lockmen, 2 months and 25½ days, at $50 per month.	142.50
			21 lockmen, 20 months and 26¼ days, at $45 per month.	939.37
			11 laborers, 3 months and 16¾ days, at $45 per month.	160.13
			2 divers, 9 days, at $7.50 per day	67.50
			1 carpenter, 4 days, at $2.50 per day	10.00
			1 scrubber, 12 days, at $1.20 per day	14.40
			3 machinists, 54 days, at $3 per day	162.00
Mar. 31	5	Board of Public Works, by F. M. Taylor, deputy recorder.	Water rent for first quarter, 1892, from January 1, to March 31, 1892 (both dates inclusive), at $9 per year.	2.25

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Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation, etc.—Continued.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
		Fourth quarter, 1892—Cont'd.		
1892. Mar. 30	6	The Richmond & Backus Company by Chas. F. Backus, secretary and treasurer.	2 dozen bottles ink, crimson, small bottles, at $1 per dozen.	$2.00
			5 quarts ink, Stafford's writing, at 55 cents per quart.	2.75
			2,000 half sheets paper, letter heads, at $3 per M.	6.00
			2 dozen penholders, at 40 cents per dozen.	.80
			2 boxes pens, Easterbrook's, No. 048, at 48 cents each.	.96
			2 boxes pens, L. Isaac's, No. 3, at $1.25 each.	2.50
			1 box pens, Gillett's, 303	.83
Apr. 16			2,000 half sheets paper, letter heads, at $3 per M.	6.00
			3,000 paper, letter, plain, at $2.20 per M.	6.60
May 4			1,000 blanks, dredging weekly	12.00
Mar. 31	7	Telephone and Telegraph Construction Company, by Hugh McMillan, treasurer.	Rent of telephone, 3 months from January 1 to March 31, 1892 (both dates inclusive), at $48 per year.	12.00
June 10	8, 9	Pay rolls, May, 1892	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			1 watchman	55.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00
			3 lockmen, 2 months 29½ days, at $60 per month.	179.00
			3 lockmen, 2 months 27 days, at $50 per month.	145.00
			21 lockmen, 20 months 26½ days, at $45 per month.	939.75
			24 laborers, 11 months 25½ days, at $45 per month.	533.25
			1 diver, ½ day, at $7.50 per day	3.75
			1 machinist, 21 $\frac{1}{10}$ days, at $3 per day	64.40
			2 teamsters with teams, 1¼ days, at $4 per day.	5.00
			1 carpenter, 27 days, at $2.50 per day	67.50
			1 scrubber, 15 days, at $1.20 per day	18.00
June 30	10	Justin E. Smith	Rent of one storage room at Detroit, Mich., from April 1 to June 30, 1892 (both days inclusive), being 3 months, at $10 per month.	30.00
		Month of July, 1892.		
July 6	1, 2	Pay rolls, June, 1892	1 superintendent	150.00
			3 assistant superintendents, at $100 per month.	300.00
			1 clerk	150.00
			1 engineman	90.00
			1 engineman	80.00
			1 engineman	75.00
			4 foremen, at $75 per month	300.00
			1 watchman	75.00
			1 watchman	55.00
			3 watchmen, at $50 per month	150.00
			2 watchmen, at $45 per month	90.00
			3 lockmen, at $60 per month	180.00
			3 lockmen, at $50 per month	150.00
			21 lockmen, at $45 per month	945.00
			16 laborers, 14 months 5 days, at $45 per month.	637.50
			1 machinist, 1¼ days, at $3 per day	5.75
			1 carpenter, 26 days, at $2.50 per day	65.00
			1 laborer, 3 $\frac{1}{10}$ days, at $2 per day	6.10
			1 scrubber, 12 days, at $1.20 per day	14.40
			Total	61,389.74

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L L 3.

DRY DOCK AT ST. MARYS FALLS CANAL, MICHIGAN.

The proposition to locate a dry dock in immediate proximity to the lockage system is as objectionable as ever; but if it should be decided to do so, then the location heretofore referred to, at the eastern end of the area transferred from the Fort Brady military reservation to the canal reservation, is the least objectionable.

But the construction of a pier in front of the Fort Brady reservation has been completed, and a portion of this work would have to be removed, thus increasing by $20,000 the probable cost of a dry dock, and the estimate therefor should be increased accordingly.

Amount (estimated) required for the construction of a dry dock at the point indicated	$343,872
Amount that can be profitably expended in fiscal year ending June 30, 1893.	150,000

Which should be added to the $65,000 (more or less) which it is understood the State of Michigan holds in readiness to transfer to the United States for the purpose of constructing a dry dock at St. Marys Falls Canal.

It may not be improper to add that I am strongly opposed to the construction of a dry dock to be operated in connection with the canal.

L L 4.

IMPROVEMENT OF HAY LAKE CHANNEL, ST. MARYS RIVER, MICHIGAN.

Before improvements were commenced the channel through Hay Lake was restricted in depth at Sugar Island Rapids and at Middle Neebish. At these two places a maximum draft of but 8 or 9 feet could be carried, if a very irregular course was taken, and, practically, vessels drawing more than 6 feet of water would not attempt the passage. In addition to the places above mentioned there were some shoals in Hay Lake requiring removal to make the channel available for vessels navigating St. Marys River.

The original estimates for this improvement were based upon a project for a channel 300 feet wide and 17 feet deep, leaving the present navigable channel of St. Marys River at Sugar Island Rapids (about 2½ miles below the canal) through those into Hay Lake, and then by way of Middle Neebish, rejoining the present navigable channel at the foot of Sugar Island, thus saving a distance of 11 miles and obtaining a route which can be so marked by lights as to be navigable by night, a condition impracticable with the present channel, except by the use of many lights.

The estimated cost of this project was $2,127,292. The project was subsequently modified to increase the navigable depth to 20 feet, the estimated cost being $2,659,115, subject to change, however, in case unexpected difficulties are developed during the progress of the work.

Prior to June 30, 1890, $975,000 had at various times been appropriated for the work. The river and harbor act of September 19, 1890, appropriated an additional $400,000 for continuing the improvement, with the provision, "That such contracts as may be desirable may be entered into by the Secretary of War for materials and labor for the entire work, or any part of the same, to be paid for as appropriations

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may from time to time be made by law," and the sundry civil act of March 3, 1891, appropriated $300,000 for continuing the improvement during the fiscal year ending June 30, 1892. The total amount appropriated up to date, therefore, is $1,675,000, with authority to contract for all or any part of the work.

EXCAVATIONS UNDER FORMER CONTRACTS.

Prior to the beginning of work under the contracts now in force, excavation had been carried on at Middle Neebish with the following results:

	Cubic yards, bank measure, excavated.
Experimental work 1882–1886	36,113.00
John Hickler, contract of February 28, 1883	201,080.00
John Hickler, contract of September 5, 1884	59,411.00
Hickler & Green, contract of May 18, 1885	65,128.00
Hickler & Green, contract of December 24, 1886	79,033.92
C. F. & H. T. Dunbar, contract of October 30, 1888	171,141.25
Total	611,907.17

In addition, 15,200 cubic yards, scow measure, were removed from the channel at Sugar Island Rapids between 1886 and 1889, and put in the cofferdam of the 800-foot lock in St. Marys Falls Canal. These amounts are exclusive of excavation outside of channel lines or below grade.

This work left the channel about in the condition shown by the map facing page 2759 of the Annual Report of the Chief of Engineers for 1891.

CONTRACTS.

List of contracts in force during fiscal year ending June 30, 1892.

Contractor.	For—	Entered into.	Remarks.
	Excavation in—		
John Hickler & Son	First section	Feb. 6, 1891	In force.
Dunbar & Sullivan	Second section	do	Do.
Carkin, Stickney & Cram	Third section	do	Do.
Do	Fourth section	do	Do.
C. F. & H. T. Dunbar	Fifth section	do	Do.
Carkin, Stickney & Cram	Sixth section	do	Do.
George Kemp	Coal and wood	Mar. 7, 1891	Closed December, 1891.
James Strachan	Machine work	do	Do.
David Wallace	Groceries	Mar. 25, 1892	Closed May, 1892.
R. G. Ferguson & Co	Hardware	do	Do.
P. M. Church & Co	Ship chandlery	do	Closed June, 1892.
George Kemp	Coal and wood	do	In force.
James Strachan	Machine work	do	Do.

PLANT.

The Government plant used on this work consists mainly of one tug, one quarter boat, ten small boats, and a sounding raft. The tug and quarter boat were placed in the lock of St. Marys Falls Canal at the close of navigation in 1891, and after the lock was pumped out they were thoroughly repaired.

The plant used by the contractors on this work during the year consisted in 1 drill boat, 16 dredges, 17 tugs, 36 dump scows, 8 flat scows, 2 floating machine shops, 7 cottages, 1 explosive factory, 1 coal vessel, 4 coaling grounds, 4 icehouses, 2 carpenter shops, 1 machine shop on shore, 4 floating boarding houses, 3 sets of ways for docking dredges and scows.

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EXCAVATION UNDER CONTRACTS STILL IN FORCE.

During the fiscal year excavation has been carried on under six contracts entered into February 6, 1891. Each of these contracts covers one of the sections into which the work has been divided, as shown on the map appended to this report. A depth of 20 feet was required except where bed rock occurred, where a depth of 21 feet was called for in order that a 20-foot navigation might be established. At the close of the fiscal year the condition of work on the different sections was as follows:

First section.—The material to be removed consisted of about 190,000 cubic yards of sand, gravel, bowlders, hardpan, and sandstone bed rock in unknown proportions, and a great deal of blasting was necessary. The depth of 21 feet is called for by the specifications; a rough stone dike, 2,040 feet in length, is required to be constructed on the north side of the channel between cross sections 286 and 490, and the contract price for excavation is $1.20 per cubic yard, bank measure, the construction of the dike being included without additional charge.

The contractors began operations May 6, 1891, and, except for interruption by the winter, work on this section has been in progress ever since. The total to June 30, 1892, of the estimates for excavation is 175,161 cubic yards, bank measure, of which 150,696 cubic yards have been excavated during the fiscal year. The dike construction required under this contract has been entirely finished, and the total length of the dike is now 6,140 feet.

Second section.—The material to be removed consisted of about 344,000 cubic yards of sand, gravel, bowlders, hardpan, and sandstone bedrock in unknown proportions, and some blasting was necessary. On bedrock the depth of 21 feet is required; elsewhere 20 feet, and the contract price is 57 cents per cubic yard, bank measure. The contractors, Messrs. Dunbar & Sullivan, began operations May 15, 1891, and, except for interruption by the winter, work on this section has been in progress ever since. The total to June 30, 1892, of the estimates for excavation is 66,875 cubic yards, bank measure, of which 57,028 cubic yards have been excavated during the fiscal year. The actual amount excavated is really much greater than this, but owing to certain conditions in the specifications the additional amount can not yet be paid for.

Third section.—The material to be removed consisted of about 1,016,000 cubic yards of silt, sand, clay, and gravel. The depth of 20 feet is required, and the contract price is 14¾ cents per cubic yard, bank measure. The contractors, Messrs. Carkin, Stickney & Cram, began operations May 27, 1891, and, except for interruption by the winter, work on this section has been in progress ever since. The total to June 30, 1892, of the estimates for excavation is 303,846 cubic yards, bank measure, of which 288,399 cubic yards have been excavated during the fiscal year.

Fourth section.—The material to be removed consisted of about 650,000 cubic yards of sand, clay, gravel, and bowlders. The depth of 20 feet is required, and the contract price is 13 cents per cubic yard, bank measure. The contractors, Messrs. Carkin, Stickney & Cram, began operations July 16, 1891, and, except for interruption by the winter, work on this section has been in progress ever since. The total to June 30, 1892, of the estimates for excavation is 329,163 cubic yards, bank measure.

Fifth section.—The material to be removed consisted of about 710,000

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cubic yards of sand, clay, gravel, bowlders, and wood. The depth of 20 feet is required, and the contract price is 14 cents per cubic yard, bank measure. The contractors, Messrs. C. F. & H. T. Dunbar, began operations June 6, 1891, and, except for interruption by the winter, work on this section has been in progress ever since. The total to June 30, 1892, of the estimates for excavation is 210,527 cubic yards, bank measure, of which 198,538 cubic yards have been excavated during the fiscal year.

Sixth section.—The material to be removed consisted of about 735,000 cubic yards of sand, clay, gravel, bowlders, and wood. The depth of 20 feet is required, and the contract price is 14¾ cents per cubic yard, bank measure. The contractors, Messrs. Carkin, Stickney & Cram, did no work on this section during the season of 1891, although twice notified to commence. Active operations were begun, however, on May 19, 1892, and by June 30, 1892, the total of the estimates for excavation is 37,907 cubic yards, bank measure.

The estimates of amounts excavated in cubic yards, bank measure, are obtained by deducting a percentage from the scow measurements. After the close of the season of 1891, soundings were made from which the actual excavation in each section at that time was determined. The results then obtained are as follows:

	Cubic yards, bank measure.
First section	152,621
Second section	64,588
Third section	184,832
Fourth section	102,715
Fifth section	140,486
Sixth section	0

The contractors for the first section were paid for the excess found over their previous estimates. By a proviso of the specifications, however, the contractors for the other sections can not be paid for any such excess until the completion of the work.

The total excavation from the channel under these six contracts up to June 30, 1892, that has been estimated and paid for, was 1,123,479 cubic yards, bank measure, of which 1,061,731 cubic yards were removed during the fiscal year. The actual amounts excavated undoubtedly exceed the above, but it is impracticable to determine them at present. Although on sections 2, 3, and 6 the amounts excavated to date are not as great as required by the specifications, still the amounts excavated from the other sections are so much greater than required as to make the total excavation exceed by a considerable amount the quantity called for.

A line of precise levels has been run from a bench mark at Middle Neebish to a bench mark at Sailors Encampment. About 300 stakes have been driven for marking the channels and dumping grounds. Twenty water gauges have been established.

The work has been under the local charge of Assistant Engineer E. S. Wheeler, with Assistant Engineer Joseph Ripley in immediate charge. The latter has been assisted in the office work by Clerk R. Common, with the instrumental work and computations by Inspectors B. Rohnert, F. C. Shenehon, and Subinspector L. P. Morrison, and in the dredge inspection by Subinspectors F. R. Hathaway, A. Thurlby, H. C. McNaughton, A. Powell, F. Kerr, G. M. Wisner, E. J. Penny, P. M. Moore, E. J. Hall, A. H. Boies, C. G. Palmer, C. H. Vaughan, P. Eagle, N. Ripley, and M. Welsh.

The advantages of the improvement have been so frequently set forth

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in preceding reports, and are so universally admitted, that it is not deemed necessary to repeat them. It is an important part of the system for the improvement of the navigation of the great lakes, and if it had been available during the fiscal year just closed, it would have been used by vessels carrying 10,107,603 tons of freight and 25,697 passengers.

The estimate for the work is $2,659,115, of which $1,675,000 has been appropriated, leaving $984,115 to be provided. To pay the various Government employés and contractors, $500,000 will be required for the fiscal year ending June 30, 1894. This amount should be appropriated, with the proviso that any portion of it not required for Hay Lake Channel could be expended elsewhere between lakes Superior and Huron, at places where excavation is needed to obtain the navigable depth of 20 feet. This entire amount can be expended to advantage during the fiscal year ending June 30, 1894.

Total expenditure to June 30, 1891	$828,823.08
Expended during fiscal year (exclusive of outstanding liabilities)	280,983.01
Total expenditure to June 30, 1892	1,109,806.09

Hay Lake Channel is in the collection district of Superior, Mich. The nearest port of entry is Marquette, but Sault Ste. Marie is a subport. The nearest lighthouse is the beacon on the pier at the western end of St. Marys Falls Canal.

Money statement.

July 1, 1891, balance unexpended		$849,695.80
June 30, 1892, amount expended during fiscal year		284,370.24
July 1, 1892, balance unexpended		565,325.56
July 1, 1892, outstanding liabilities	$84,820.07	
July 1, 1892, amount covered by uncompleted contracts	480,505.49	
		565,325.56
Amount appropriated by act approved August 5, 1892		115,000.00
Amount (estimated) required for completion of existing project		869,115.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriations for improving Hay Lake Channel, Sault Ste. Marie River, Michigan.

August 2, 1882	$200,000
July 5, 1884	125,000
August 5, 1886	150,000
August 11, 1888	500,000
September 19, 1890	400,000
March 3, 1891, sundry civil bill	300,000
Total	1,675,000

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Abstract of bids for supplies for improving Hay Lake Channel, St. Marys River, Michigan, received and opened March 14, 1892, in accordance with advertisement dated February 23, 1892.

No.	Name and address of bidder.	Supplies.	Total.
1	R. G. Ferguson & Co., Sault Ste. Marie, Mich	Hardware	*$65.17
2	P. M. Church & Co., Sault Ste. Marie, Mich	do	67.91
3	Hodgson & Howard, Detroit, Mich	do	80.78
4	T. B. Rayl & Co., Detroit, Mich	do	81.05
1	P. M. Church & Co., Sault Ste. Marie, Mich	Ship chandlery	*629.42
2	R. G. Ferguson & Co., Sault Ste. Marie, Mich	do	650.54
1	David Wallace, Detroit, Mich	Groceries	*219.97
2	G. & R. McMillan & Co., Detroit, Mich	do	221.83
3	P. C. Keliher, Sault Ste. Marie, Mich	do	222.63
4	Prenzlauer Bros., Sault Ste. Marie, Mich	do	264.66
1	do	Meats and vegetables.	†703.75
1	George Kemp, Sault Ste. Marie, Mich	Coal, etc	*565.00
2	T. C. Anthony, Sault Ste. Marie, Mich	do	588.50

No.	Name and address of bidder.	Machine work, per hour.					
		Lathe, 100 hours.	Planer, 100 hours.	Steam hammer, 100 hours.	Bolt-cutter, 100 hours.	Power drill, 100 hours.	Total.
		Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	
1	James Strachan, Sault Ste. Marie, Mich	40	30	70	30	30	*$290

* Recommended for acceptance. † Recommended to be rejected, the prices being too high.

L L 5.

IMPROVEMENT OF HARBOR AT CHEBOYGAN, MICHIGAN.

Prior to undertaking any improvement at this harbor only 6½ to 7 feet of water could be carried across the bar at the mouth of Cheboygan River.

The original project for the improvement, adopted in 1871, contemplated dredging a channel 200 feet wide and 14 feet deep throughout the bar, and revetting each side by a pile pier. Experience gained during the progress of the work already done leads to the belief that the piers can be omitted with consequent reduction of cost to the extent of one-half the original estimate.

Subsequent modifications of the project were made until, as it finally stood, it provided for a channel of 15 feet in depth and generally 200 feet in width from the 15-foot curve in the Straits of Mackinac to the State Road Bridge.

This has been completed, and until the dredged channel begins to silt up, or the revetting piers contemplated in the original project of 1871 are shown to be necessary, no further work is proposed, and therefore no further estimate is submitted at this time.

Total expenditure to June 30, 1891	$129,706.03
Expended during fiscal year	12.70
Total expenditure to June 30, 1892	129,718.73

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The work is in the Michigan collection district, Michigan. The nearest port of entry is Grand Haven, Mich., and the nearest light-house stands on the pier head marking the outer end of the channel.

Money statement.

July 1, 1891, balance unexpended	$18,340.43
June 30, 1892, amount expended during fiscal year	12.70
July 1, 1892, balance unexpended	18,327.73

Appropriations for improving harbor at Cheboygan, Mich.

March 3, 1871	$10,000	June 14, 1880	$6,000
June 10, 1872	15,000	March 3, 1881	6,000
March 3, 1873	15,000	August 2, 1882	10,000
June 23, 1874	15,000	July 5, 1884	5,000
March 3, 1875	15,000	August 5, 1886	15,000
August 14, 1876	10,000	August 11, 1888	15,000
June 18, 1878	8,000		
March 3, 1879	3,000	Total	148,000

COMMERCIAL STATISTICS.

Commerce of the harbor at Cheboygan, Mich., for the season of 1891.

[Compiled from the report of Mr. Jno. W. Loucks, deputy collector of customs.]

Articles.	From custom-house books.		From warehouse books.		Total tons.
	Quantities.	Tons.	Quantities.	Tons.	
Shipments.					
Lumber:					
Pine ... feet B. M.	115,974,607	173,961	3,000,000	4,500	178,461
Hardwood ... do.	1,723,000	3,876			3,876
Lath, pine ... pieces	15,988,550	3,997	2,500,000	625	4,622
Railroad ties, cedar ... do.	236,600	11,830			11,830
Paving posts ... do.	313,619	7,840			7,840
Shingles, pine ... do.	5,136,000	898	35,000,000	6,125	7,023
Telegraph poles, cedar ... do.	1,900	285	1,500	225	510
Tan bark, hemlock ... cords	1,442	1,081			1,081
Miscellaneous				7,000	7,000
Total shipments		203,768		18,475	222,243
Receipts.					
Wheat ... bushels	11,700	351			351
Corn ... do.	5,000	140			140
Oats ... do.	41,500	664			664
Coal, hard and soft ... tons		5,861			5,861
Feed, in sacks ... bags	1,513	75			75
Oil ... barrels	500	100	1,200	240	340
Hay, baled ... tons		537			537
Salt ... barrels			2,000	300	300
Cement ... do.			500	75	75
Land plaster ... do.			300	45	45
Lime ... do.			2,000	200	200
Miscellaneous				15,000	15,000
Total receipts		7,728		15,860	23,588
Aggregate					245,831

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Vessels entered and cleared.

	No.	Tonnage.
Entered:		
Steam	391	103,981
Sail	299	79,325
Total	690	183,306
Cleared:		
Steam	393	104.108
Sail	301	80.136
Total	694	184.244
Aggregate	1,384	367,550

Steamers trading at port of Cheboygan, but not entered or cleared.

	Trips.	Tonnage.	Total tonnage.
Steamer—			
City of Alpena	140	1,221	170,940
City of Mackinac	118	807	95,226
Flora	60	455	27,300
Propeller—			
Atlantic	70	556	38,920
Fanny C. Hart	86	476	40,936
Romeo	100	47	4,700
Juliet	100	47	4,700
Total	674	3,609	382,722

L L 6.

IMPROVEMENT OF HARBOR AT THUNDER BAY, MICHIGAN.

Prior to the commencement of improvements there was a navigable channel from Thunder Bay into the river of 12 feet depth and of a variable width, which at one place was only 50 feet. The original project for the improvement of the harbor was adopted in 1876, and provided for an entrance channel from the bay into the river of navigable width and of not less than 13 feet depth, a subsequent modification increasing the proposed depth to 14 feet.

The work was practically completed in 1884, but it was then stated that the improvement was of such a character that it would require attention from time to time, and it was recommended that a sufficient appropriation be made to render $10,000 available for use when it should be wanted.

On June 30, 1891, a channel about 150 feet wide and 14 feet deep extended across the bar, and dredging to restore the 14-foot channel, in accordance with the river and harbor act of September 19, 1890, was still in progress under contract with the Bay City Dredging Company, dated April 9, 1891.

Work under this contract was continued until October 20, 1891, by which time a total of 23,954 cubic yards, scow measure, had been excavated from the harbor under the contract, of which 17,083 cubic yards were removed during the fiscal year. As a result of this dredging the depth of 14 feet was restored for a width of about 250 feet entirely across the bar. In addition, one dredge cut 16 feet deep and 20 feet wide extended entirely across the bar, and two more dredge cuts of the same depth were partially finished adjacent to it.

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In order that the depth of 16 feet that has been obtained in the river may be rendered available, the next appropriation should be expended in deepening the channel across the bar to the full depth of 16 feet for a suitable width. The river and harbor act of September 19, 1890, making separate appropriations for the river and the harbor, seemed to require an absolute division between the two, and this division was made abreast of the light-house crib. It is evident, however, that the intent of the law was to render the 16-foot depth required in the river available to commerce, and should no such distinction be made again between the two portions of the work, future appropriations should be expended with this understanding.

The river and harbor act of September 19, 1890, although separating the work into two portions—permitted the grouping in one contract of all the work of a similar character situated in the same region. A dredge could therefore be used on this work to the best advantage by working in the harbor during fair weather and in the river during bad weather. By being thus prevented from lying idle the cost of the work was reduced nearly one-half.

In view of the commercial importance of the city of Alpena, which is situated at the mouth of the river, the river and harbor are well worthy of the additional appropriation of $20,587.48, which, if made at one time, and not restricted as to the portion of the work on which it must be expended, will probably suffice to make a continuous depth of 16 feet. This entire amount can be profitably expended during the fiscal year ending June 30, 1894.

Total expenditure to June 30, 1891	$20,785.81
Expended during fiscal year	3,403.69
Total expenditure to June 30, 1892	24,189.50

Thunder Bay River is in the collection district of Huron, Mich. The nearest port of entry is Port Huron, and the nearest light-house is at the work.

Money statement.

July 1, 1891, balance unexpended	$5,372.50
June 30, 1892, amount expended during fiscal year	4,548.87
July 1, 1892, balance unexpended	823.63
Amount (estimated) required for completion of combined projects for Thunder Bay River and harbor	10,587.48
Amount that can be profitably expended in fiscal year ending June 30, 1894	10,587.48

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriations for improving harbor at Thunder Bay, Michigan.

August 14, 1876	$4,500
August 2, 1882	15,000
September 19, 1890	5,500
	25,000

COMMERCIAL STATISTICS.

It has been impracticable to obtain statistics for the calendar year 1891, but they are believed to be substantially the same as for the preceding year, when the commerce of Alpena, Michigan, at the mouth of Thunder Bay River, was estimated at 500,000 tons and its value at over $5,000,000.

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L L 7.

IMPROVEMENT OF THUNDER BAY RIVER, MICHIGAN.

Before improvements were commenced Thunder Bay River, from its mouth to 1 mile above, varied in width from 175 to 100 feet, and had a navigable channel of from 14 to 11 feet deep except at the upper end, where the depth diminished to 5 feet.

The general project for the improvement of the river contemplates a channel 16 feet deep within the dock lines established by the city engineer of Alpena, Mich., in 1888, the width varying from 100 to 50 feet, according to locality, and the channel extending from the mouth of the river to a point 1 mile above.

On June 30, 1891, one dredge cut, about 25 feet wide and 16 feet deep, extended upon the northerly side of the axis of the river from the light-house crib at the mouth to the Second Street Swing Bridge in Alpena, a second dredge cut had been made upon the southerly side of the axis for about half this distance, and work was still in progress under contract with the Bay City Dredging Co., dated April 9, 1891.

Work was continued until November 24, 1891, when a total of 40,791 cubic yards, scow measure, had been excavated under the contract, of which 33,370 cubic yards were removed during the fiscal year, and a channel 16 feet deep and from 100 to 50 feet wide extended from the mouth of the river to a point about seven-eighths of a mile above. At this point bed rock was struck, and the cost of farther extending the channel will be too great to be warranted by the possible benefits that might be derived from so doing.

In order that the depth of 16 feet obtained in the river may be rendered available, the next appropriation should be expended in deepening the channel across the bar at its mouth to the full depth of 16 feet for a suitable width. The river and harbor act of September 19, 1890, making separate appropriations for the river and the harbor, seemed to require an absolute division between the two, and this division was made abreast of the light-house crib. It is evident, however, that the intent of the law was to render the 16-foot depth required in the river available to commerce, and should no such distinction be made again between the two portions of the work, future appropriations should be expended with this understanding.

The river and harbor act of September 19, 1890, although separating the work into two portions, permitted the grouping in one contract of all work of a similar character situated in the same region. A dredge could therefore be used on this work to the best advantage by working in the harbor during fair weather and in the river during bad weather. By being thus prevented from lying idle, the cost of the work was reduced nearly one-half.

In view of the commercial importance of the city of Alpena, which is situated at the mouth of the river, the river and harbor are well worthy of the additional appropriation of $20,587.48, which, if made at one time, and not restricted as to the portion of the work on which it must be expended, will probably suffice to make a continuous depth of 16 feet. This entire amount can be profitably expended during the fiscal year ending June 30, 1894.

Total expenditure to June 30, 1891	$1,724.10
Expended during fiscal year	6,996.20
Total expenditure to June 30, 1892	8,720.30

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Thunder Bay River is in the collection district of Huron, Mich. The nearest port of entry is Port Huron, Mich., and the nearest light-house is at the mouth of the river.

Money statement.

July 1, 1891, balance unexpended	$9,608.50
June 30, 1892, amount expended during fiscal year	8,328.80
July 1, 1892, balance unexpended	1,279.70
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	11,279.70

Amount (estimated) required for completion of existing project*.....
Amount that can be profitably expended in fiscal year ending June 30, 1894*
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriations for improving Thunder Bay River, Michigan.

September 19, 1890 ..... $10,000

COMMERCIAL STATISTICS.

It has been impracticable to obtain statistics for the calendar year 1891, but they are believed to be substantially the same as for the preceding year, when the commerce of Alpena, Mich., at the mouth of the river, was estimated at 500,000 tons and its value at over $5,000,000. A large portion of this commerce enters Thunder Bay River, but it is impossible to determine its amount.

L L 8.

IMPROVEMENT OF HARBOR AT AU SABLE, MICHIGAN.

Before the beginning of improvements the mouth of Au Sable River was 150 feet wide, with a depth of 5 feet over the bar. Above the mouth for a quarter of a mile 7 to 10 feet of water was found, and above this point only 5 or 6 feet.

The present project for the improvement of the harbor was adopted in 1866 and modified in 1879, the object being to obtain a channel of not less than 10 feet in depth for a width of 100 feet from Lake Huron to the State Road Bridge at Au Sable.

The money heretofore expended on this improvement has given temporary results only, and a permanent channel can not be secured except at so great a cost as to be disproportionate to the benefits to be obtained.

The shipments from this port are large and important, but are principally made from private piers built into the lake entirely outside of the harbor. Were there a fair prospect of securing a permanent improvement at a reasonable cost I would take pleasure in recommending further appropriations for this harbor, but can not clearly see my way to doing so.

Total expenditure to June 30, 1892 ..... $114,786.12

This work is in the collection district of Huron, Mich. The nearest port of entry is Port Huron and the nearest light-house is at the work.

* See Thunder Bay Harbor.

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Money statement.

July 1, 1891, balance unexpended	$200.55
June 30, 1892, amount expended during fiscal year	4.05
July 1, 1892, balance unexpended	196.50

Appropriations for improving Au Sable River and Harbor, Michigan.

River:		River—Continued.	
March 2, 1867	$50,000	March 3, 1879	$7,000
April 10, 1869	2,970	June 14, 1880	7,000
July 11, 1870	15,000	Harbor and river:	
March 3, 1871	10,000	March 3, 1881	6,000
June 10, 1872	10,000	August 2, 1882	5,000
June 23, 1874	1,000		
August 14, 1876	1,000	Total	114,970

COMMERCIAL STATISTICS.

Number of vessels	604
Registered tonnage	218,327

Principal products shipped from the harbor at Au Sable, Michigan, during the calendar year 1891.

Article.		Quantity.	Tons.
Lumber	feet, B. M.	219,461,000	329,191
Lath	pieces	6,164,000	1,541
Shingles	do	23,028,000	3,454
Salt	barrels	285,746	42,862
Cedar posts	pieces	202,174	3,235
Railroad ties	do	26,000	4,300
Telegraph poles	do	56,274	28,137
Total			412,720

The above was compiled from records kept by Mr. Granger Hill, deputy collector of customs, Oscoda, Mich.

L L 9.

IMPROVEMENT OF SAGINAW RIVER, MICHIGAN.

Before the improvements were begun, the entrance to Saginaw River was obstructed by a bar in Saginaw Bay about a mile from shore and a half mile in width between the 10-foot curve, with a minimum depth of about 9 feet. Between the mouth of the river and Bay City, a distance of about 5 miles, the depth varied from 15 to 30 feet. Thence to the head of the river, a further distance of about 16 miles, the channel was obstructed by a number of bars, having only 7 feet of water upon them, thus limiting the navigable depth to about 7 feet, although the prevailing depth varied between 12 and 20 feet.

The original project for the improvement of the river was adopted in 1876. Various additions were subsequently made to it until 1882, when

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a Board of Engineers recommended that a channel be made 200 feet wide with a depth of 14 feet from Saginaw Bay to Bay City and with a depth of 12 feet thence to the head of the river, a total distance of about 23 miles.

Additions to this project have been made at various times. These provided for the repair, extension, and reconstruction of the revetment, confining the Carrollton Channel, and for the construction of similar works at the head of Crow Island for the improvement of Zilwaukee Bar.

On June 30, 1891, dredging was in progress on the bar at the mouth of the river and at Zilwaukee Bar, and repair work at Carrollton revetment and extension of wing dam.

During the fiscal year the following contracts were in force, all under the appropriation of September 19, 1890:

Contractor.	Contract for—	Entered into.	Remarks.
Thomas M. Hubbell	Dredging above Bay City	Feb. 21, 1891	Closed Dec. 7, 1891.
John G. Owen	Timber and plank	do	Closed Nov. 6, 1891.
Carkin, Stickney & Cram	Iron bolts and nails	do	Closed Oct. 5, 1891.
McCollum & Lee	Dredging bar at mouth	Apr. 9, 1891	In force.

The progress made during the fiscal year was as follows:

Excavated on the bar at the mouth, 75,982 cubic yards, scow measure, costing, at the contract price of 34 cents per cubic yard, $25,833.88. Work not yet completed.

Excavated at Zilwaukee Bar, 25,368 cubic yards, scow measure, costing, at the contract price of 36 cents per cubic yard, $9,132.48 and resulting in a channel 200 feet wide and 12 feet deep for the whole extent of the bar.

Excavated at Bristol Street Bridge, in the city of Saginaw, 13,019 cubic yards, scow measure, costing, at the contract price of 36 cents per cubic yard, $4,686.84, resulting in a navigable channel 12 feet deep and 2 dredge cuts wide nearly half a mile in length.

Excavated from the channel of Saginaw River below Melbourne, 23,623 cubic yards, scow measure, costing, at the contract price of 36 cents per cubic yard, $8,504.28.

The burnt superstructure of the Carrollton revetment was repaired, as well as the wrecked portion of the lower end of the old wing dam at the head of Crow Island, and the latter was extended downstream, terminating upon the west shore of the island. The original length of the wing dam was 900 feet. It is now 1,685 feet long, with a shore arm 32 feet long.

The present condition of the improvement is as follows:

1. Bar at mouth of the river.—A channel 14 feet in depth and about 160 feet wide has been made across the crest of the bar from deep water at the mouth of the river to a point on the light-house range—or axis of the proposed channel—12,300 feet from the front light, terminating in 13 feet of water; thence northward one dredge cut, 14 feet deep and about 22 feet wide, nearly on range and east of axis, extends 3,800 feet farther to the 14-foot curve in Saginaw Bay.

The last survey of the channel was made in January and February, 1891. It was then found that in order to complete the width of the 14-foot channel to the projected 200 feet, and extend it to the 14-foot curve, which is at a distance of 16,100 feet from the front light, it will be necessary to remove about 180,000 cubic yards of material, two-thirds

of which is hard clay, and one-half of it with a face of only 1.5 feet. The examination also developed the fact that the crest of the bar along the east side of the channel is slowly but constantly being raised by accumulation of sand, and even deposit of sewage brought down by the current from the cities above, causing the east bank of the dredged channel to cave in for a linear distance of about 2,000 feet. The dredging records show that the second, third, and fourth dredge cuts east of the range line have been, and the last named is now, being dredged for the third time to 14 feet depth of water.

2. *Essexville Bar.*—This bar has come into special notice only within the last two years, and the cost of its improvement was not included in the original estimate. It was surveyed in February last. To make a channel across it 14 feet deep and 200 feet wide will require the removal of 48,000 cubic yards of material, and the resulting channel will be about 3,000 feet long.

3. *Bay City front.*—No complaints regarding the uncompleted channel at this locality have reached this office since the last dredging was done there in 1885. Based upon an examination made in 1884, and the dredging done during that and the subsequent season, it is estimated that the removal of 41,564 cubic yards will be required to complete the project.

4. *Shoal below Melbourn.*—This shoal is nearly a mile in length. Dredging on it was commenced in 1891. To complete a channel 12 feet deep and 200 feet wide will require the removal of 74,137 cubic yards of material in addition to that already taken out. This estimate is based upon the ice survey of February, 1891, and takes no account of any deposits that have been subsequently made, nor of any that may occur hereafter.

5. *Willow Island.*—No dredging has been done at this locality since 1884. When operations ceased at that time the removal of 35,796 cubic yards of material was required to complete the project. No complaints as to this portion of the improvement have reached this office since that time.

6. *New York Works Bar.*—During the last two seasons loaded vessels frequently grounded on this bar. An ice survey made in January, 1892, revealed the fact that the channel is in an unsatisfactory condition, notwithstanding the considerable amount of dredging that has been done upon it during previous years. Based upon the survey referred to, it is estimated that the excavation of 79,400 cubic yards of sand will be required to make a channel 12 feet deep and 200 feet wide; and it appears somewhat doubtful whether this improvement can be made permanent without supplementary works involving the construction of a wing dam, or equivalent works.

7. *Zilwaukee Bar.*—During the fiscal year a channel 12 feet deep and 200 feet wide was completed across this bar, and the wing dam, intended as a protection to the channel, was extended from its original length of 900 feet to its present length of 1,685 feet. It is hoped and expected that the channel will prove to be permanent.

8. *Carrollton Bar.*—The extension of the United States revetment on east side and the beam wall on the west side, downstream to deep water, has caused the channel between them to scour, so that there is now a channel of nearly uniform depth of 12 feet. It is possible that no further expenditure will be required at this point beyond what is necessary to keep the structures in repair.

9. *Saginaw (E. S.) river front.*—A survey of this locality was made in January, 1892, from which it was learned that while there are small

areas having a depth of 12 feet along the track followed by tugs in towing rafts, yet these areas are not connected. The bottom consists of fine sand, and the efforts so far made to secure a channel of the projected depth have not been successful. It is estimated that a channel 12 feet deep and 200 feet wide will involve the excavation of about 86,000 cubic yards of material. Whether such a channel would be permanent is quite doubtful.

10. Bristol Street Bridge Shoal.—The improvement of this reach of the river was begun during the season of 1891. A survey made in January, 1892, shows that the channel had not deteriorated during the intervening two months. Based upon the survey referred to, it is estimated that to obtain a channel 12 feet deep and 200 feet wide will involve the removal of 49,300 cubic yards of sand. Whether it will be permanent when made is very doubtful.

11. South Saginaw.—Nothing has yet been done toward improving the long reach of river immediately above Mackinaw Street Bridge. In order to make a channel 12 feet deep and 200 feet wide at this locality will require the removal of about 100,000 cubic yards of material, and it is probable that once made it will require frequent redredging to maintain it.

12. West Channel along West Bay City.—This is not a part of the original project. The sum of $15,000 has been expended in dredging it and at the date of the latest survey (in January, 1891) it was found in much better condition than expected. It can not be regarded as permanent, however.

Summary.—The amount of material yet to be removed to complete the project is estimated at about 640,000 cubic yards, at an estimated cost of $281,203. But it is perfectly well understood that considerable portions of the work can never be considered as permanently completed, and that more or less dredging will always be required after each spring freshet at a probable cost of not less than $5,000 per year.

The appended report by Assistant Engineer B. H. Muehle, gives much information in detail necessarily omitted from this. Particular attention is invited to his schedule of dredging heretofore done, and estimates of that required to complete the original project; including $10,000 for the West Channel along West Bay City, and $18,500 for improving Essexville Bar, neither of which were comprised in the original estimates. It will be observed that the total exceeds the balance yet due from the original estimates; but if the amounts already expended upon the West Channel along West Bay City, the amount herein estimated for its further improvement, the amount of the estimate for the Essexville Bar, the amounts of the annual expenditures already made and hereafter to be made for redredging—referred to in the original report as necessary, and estimated at $5,000 per year—and the amounts expended in keeping the several revetments and wing dams in repair, and the sum of the incidental expenses pertaining to all these be aggregated and the total deducted (as it should be done) from the balance required as shown by the schedule, the remainder will be found to fall within the proportion of the original estimates yet remaining to their credit.

During the fiscal year ending June 30, 1893, the sum of $150,000, including $10,000 for West Channel along West Bay City and $18,500 for Essexville Bar, can be profitably expended upon the improvement.

Total expenditures to June 30, 1891	$503,331.78
Expended during fiscal year (exclusive of outstanding liabilities)	52,326.00
Total expenditures to June 30, 1892	555,657.78

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Saginaw River is in the collection district of Huron, Mich. The nearest port of entry is Port Huron. The nearest light-house is at the mouth of the river.

Money statement.

July 1, 1891, balance unexpended		$73,727.42
June 30, 1892, amount expended during fiscal year		61,109.73
July 1, 1892, balance unexpended		12,617.69
July 1, 1892, outstanding liabilities	$8,310.45	
July 1, 1892, amount covered by uncompleted contracts	3,352.50	
		11,662.95
July 1, 1892, balance available		954.74
Amount appropriated by act approved July 13, 1892		100,000.00
Amount available for fiscal year ending June 30, 1893		100,954.74
Amount (estimated) required for completion of existing project		68,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		68,250.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.		

Appropriations for improving Saginaw River, Michigan.

June 23, 1866	$67,500	June 14, 1880	$15,000
March 2, 1867	28,000	March 3, 1881	10,000
July 25, 1868	9,000	August 2, 1882	125,000
July 11, 1870	1,500	July 5, 1884	50,000
June 23, 1874	15,000	August 5, 1886	33,750
March 3, 1875	30,000	August 11, 1888	65,000
August 3, 1876	11,000	September 19, 1890	75,000
June 18, 1878	25,000		
March 3, 1879	8,000	Total	568,750

REPORT OF MR. B. H. MUEHLE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 1, 1892.

GENERAL: I have the honor to submit my annual report upon the work of improving Saginaw River, Michigan, for the fiscal year ending June 30, 1892.

Several works of improvement, in continuation of the approved general project, were in progress at the beginning of the fiscal year, involving the expenditure of the sum of $75,000 appropriated by act of Congress dated September 19, 1890, one-half of which sum was to be expended "above Bay City."

The following contracts were in force on July 1, 1891:

1. McCollum & Lee, Welland, Ontario, dated April 9, 1891, for dredging channel across the bar at the mouth of the Saginaw River, at 34 cents per cubic yard, scow measurement.

2. Thomas M. Hubbell, Detroit, Mich., dated February 21, 1891, for dredging channels "above Bay City," at 36 cents per cubic yard, scow measurement.

3. John G. Owen, Saginaw, Mich., dated February 21, 1891, for furnishing and delivering pine timber at $20, pine plank at $14, and hemlock plank at $9.25 per 1,000 feet, board measure.

4. Carkin, Stickney & Cram, of Saginaw, Mich., dated February 21, 1891, for furnishing and delivering wrought-iron screw and washer bolts and tie-rods at $4.19, and cut nails at $2.98 per pound.

The improvements which were made under these contracts during the fiscal year are described as follows:

1. *Channel across the bar at the mouth of the river.*—The contractors, with one dredge, one tug, and two dump scows, continued the fourth cut west of the range line or axis of the proposed 200-foot channel, northward to the 13-foot curve which is found

at a distance of 12,300 feet from the front range light; brought the unfinished first, second, and third cuts to the same terminus, and made a complete second and partial third cut east of the range, closing operations for the season of 1891 on November 21, 1891. By authority of the Chief of Engineers—the contract having been extended to August 15, 1892—the contractors resumed dredging on the 21st day of April, 1892, and continued it to the end of the fiscal year; completing the third cut east of range to the 13-foot curve, and extending the fourth cut to a point 11,200 feet distant from the front range light. All excavated material was dumped in Saginaw Bay, about 1 mile east of the outer end of the dredged channel. The result of the work of dredging under this contract may be summarized as follows:

	Date.	Linear feet.	Cubic yards.
Fourth cut west	July 1–Sept. 21, 1891	5,859	17,821
Third cut west	Aug. 29–Sept. 21, 1891	1,332	3,734
Second cut west	Aug. 15–26, 1891	1,371	2,792
First cut west	Aug. 22–25, 1891	364	578
Second cut east	Sept. 26–Nov. 7, 1891	8,540	16,550
Third cut east	Nov. 7–21, 1891	2,610	5,846
Do	Apr. 21–June 8, 1892	4,724	13,661
Fourth cut east	June 8–30, 1892	4,320	15,000
Total			*75,982

* The removal of which cost, at the contract price of 34 cents per cubic yard, the sum of $25,833.88.

2. *Channel "above Bay City."*—Under contract with Thomas M. Hubbell, dredging was continued at the beginning of the fiscal year with one dredge in the channel across the Zilwaukee Bar at the head of Crow Island. This work was completed October 3, 1891, a channel 200 feet wide and 12 feet deep having been made in accordance with the approved project, by excavating 25,368 cubic yards of sand, at a cost of $9,132.48. The same dredge was then employed in commencing the improvement of the channel across a shoal at the Bristol Street Bridge, in the city of Saginaw, for which a special allotment was made from the appropriation for Saginaw River "above Bay City." Between September 17 and November 2, 1891, 13,019 cubic yards of sand were excavated at an expense of $4,686.84, resulting in a navigable channel 12 feet deep and two dredge-cuts wide, and nearly half a mile in length. On the 12th of August, 1891, the same contractor furnished a second dredge, as he was required to do by the terms of the specifications. This dredge was used in improving the channel of Saginaw River below Melbourne, and worked there continuously until November 27, 1891, when the season's operations were terminated on account of the formation of ice, and the contract was closed. On the 2d of November, 1891, the first dredge joined the plant at Melbourne, and worked there to the end of the season. The operations at Melbourne resulted in making a navigable channel 12 feet deep, 85 feet wide, and about 2,575 feet long across the crest of the shoal immediately below the Melbourne lumber docks, this partially removing the most serious obstruction to navigation in this locality. The dredges excavated 23,623 cubic yards, at a cost of $8,504.28.

The total amount of dredging done, under contract with Thomas M. Hubbell during the fiscal year, was 62,010 cubic yards, and its cost $22,323.60.

A small portion of the excavated material, principally clay, was put into dump scows and carried a distance of about 14 miles to the dumping ground in Saginaw Bay; another portion was transferred to the City Hall Dock and grounds, adjacent to the Bristol Street Bridge, in the city of Saginaw, and the balance dumped in various private slips, and with the aid of an elevator dredge, redredged and used for filling lumber docks, wharves, and swamp land. The following schedule shows the quantities thus disposed of:

	Cubic yards.
Saginaw Bay dumping ground	19,948
City Hall Dock, Saginaw	13,355
Behind Beam Wall, at Crow Island	11,408
Mershons Slip	9,601
Eastmans Slip	7,401
On revetment at Carrollton	297
Total	62,010

It is deemed appropriate in this connection to note the fact that the selection of a suitable place of deposit for the excavated material is a difficult problem to solve when projects for improving Saginaw River "above Bay City" are being made.

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The comparatively high price per cubic yard (36 cents), at which the last contract was let to the lowest bidder—other bids having been 39, 40, and 42¼ cents, respectively—is readily accounted for when it is considered that the Government can furnish no more convenient dumping ground than the one in Saginaw Bay; and the contractor is required to remove the dredged material the best way he can; subject, however, to restrictions as to dumping in the channel or near it, for the purpose of redredging, and to selection of all places of deposit.

The repairs of the burnt portion of the Carrollton revetment and the repairs and extension of the wing dam at the head of Crow Island were in progress at the beginning of the fiscal year, and were completed at the end of October, 1891. The timber, plank, and iron materials were furnished under the contracts hereinabove specified, and the work done by hired labor. The following materials were furnished and delivered during the fiscal year:

By John G. Owen:	
15,264 feet, B. M., pine timber, at $20 per M	$305.28
4,037 feet, B. M., pine plank, at $14 per M	56.52
20,448 feet, B. M., hemlock plank, at $9.25 per M	189.14
	550.94
By Carkin, Stickney & Cram:	
354 tie rods, 1¼ inches by 14 feet 6 inches, 19,387 pounds, at 4.19 cents	812.31
56 tie rods, 1¼ inches by 6 feet 6 inches, 1,822 pounds, at 4.19 cents	76.34
77 screw bolts, 1¼ inches by 38 inches, 1,335 pounds, at 4.19 cents	55.94
60 kegs 8-inch cut nails, 6,000 pounds, at 2.98 cents	178.80
	1,123.39

The following amounts were expended for materials and labor on repairs:

	At Carrollton.	At Wing Dam.
For timber and plank	$204.00	$335.22
For tie rods, bolts, and nails	812.31	311.08
For labor	1,197.45	646.52
Total	2,213.76	1,292.82

The work of repairing the Carrollton revetment consisted in stripping off the burnt superstructure, removing part of the old filling, then topping and facing the old piles and bolting waling timber to the front row by means of wrought iron tie rods, connecting with the piles in the rear row, and by means of short screw and washer bolts with intermediate piles in the front row. The beam wall extension of the wing dam at the head of Crow Island, was designed as an additional protection and for securing greater permanency of the adjacent dredged channel. The wrecked portion of the lower end of the old wing dam (originally 900 feet long) having been removed by the dredge, and a trench excavated along the site of the proposed extension, the beam wall was built on a slight curve downstream terminating upon the west shore of Crow Island. The entire length of the wing dam and extension is now 1,685 feet, with a shore arm 32 feet long. The old wing dam was strengthened by means of tie rods 6 feet 6 inches long, connecting the front row with the rear row of piles at intervals of 15 feet.

The steam launch *Ethel*, temporarily transferred from the Harbor of Refuge, Lake Huron, to the Saginaw River improvement on July 5, 1889, was in commission from the beginning of the fiscal year to the end of the season of navigation of 1891. Her running expenses during that time were paid out of two different allotments of the appropriation for Saginaw River, as follows:

	General appropriation.	Above Bay City.	Total.
Salaries of master and engineman	$765.00	.....	$765.00
Labor on repairs, cleaning boiler, etc	3.00	$56.25	59.25
Supplies:			
Coal	89.25	20.25	109.50
Materials for repairs	7.45	5.67	13.12
	864.70	82.17	946.87

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The launch was used almost daily, transferring materials and men engaged on the works of improvement, during examinations and surveys incident thereto, and on trips of inspection by the assistant engineer between the city of Saginaw and the mouth of the river. At the close of the season of 1891 the launch was laid up, and, with other United States property, placed in charge of a watchman at Zilwaukee. Her hull was slightly damaged by the ice, and frequent pumping did not keep her afloat, so that she was allowed to settle to the river bottom, in shoal water. Partly on account of this damage and partly of her having been found unsuitable and inadequate for the service required, owing to insufficiency of speed, it was deemed advisable to dispose of her at the opening of the season of 1892, and her sale at public auction was ordered by the Chief of Engineers, under date of June 6, 1892. June 28, 1892, the boat was sold, accordingly, for the sum of $250.

During the months of January and February, 1892, ice surveys were made in accordance with your instructions dated January 11, 1892, at the following places in Saginaw River:

1. Shoal at Bristol Street Bridge, in the city of Saginaw.
2. River front of Saginaw (east side) below the Genesee avenue and the Flint and Pere Marquette Railroad bridges.
3. Shoal at the New York Works.
4. Shoal near the mouth of the river, between the light-houses and the village of Essexville.

Maps of these surveys were made by me during the closing months of the fiscal year, together with computations of quantities of materials yet to be removed by dredging, in order to complete the present approved project for improving Saginaw River.

Based on the latest examinations of the different localities, I have prepared a description of the present condition and brief history of all the obstructions to navigation in Saginaw River, for the purpose of showing how complicated, difficult, and costly the river improvement has been and will continue to be until such time as it may be considered satisfactorily and finally completed.

The approved project consists in providing a dredged channel 14 feet deep and 200 feet wide from Saginaw Bay to the Portsmouth Bridge at South Bay City, and thence a channel 12 feet deep and 200 feet wide to the head of navigation, a distance of 25 miles.

The first-named reach of river has been entitled the "General improvement" and the other "above Bay City." This separation is due to the fact that the Saginaw River flows through two Congressional districts, the Representatives of which have always preferred a division of the appropriation for Saginaw River, and have the amounts particularly specified in every river and harbor bill passed by Congress; so that, even though there is but one general project for the improvement of the river, its execution is regulated by the terms of the appropriations, and forms two separate sections of the work.

A. GENERAL IMPROVEMENT.

1. Bar at mouth.—This is unquestionably the most important part of the improvement, providing as it does for the passage of all vessels navigating the Saginaw River across the outer bar to and from Saginaw Bay and Lake Huron. A channel of 14 feet in depth and about 160 feet wide has thus far been made across the crest of the bar from deep water at the mouth of the river, to a point on the light-house range, or axis of the proposed channel, 12,300 feet from the front light, terminating in 13 feet of water; thence northward one dredge cut 14 feet deep and about 22 feet wide, nearly on range and east of the axis, extends 3,800 feet farther to the 14-foot curve of soundings in Saginaw Bay.

The last survey of the channel was made in January and February, 1891; it was found that in order to complete the width of the 14-foot channel to the projected 200 feet and extend it to the 14-foot curve—which is at a distance of 16,100 feet from the front light—it will be necessary to excavate 180,000 cubic yards, two-thirds of which is hard clay, and one-half of this with only 1.5 feet depth of excavation or face. The examination also developed the fact that the crest of the bar along the east side of the channel is slowly but constantly being raised by accumulation and deposit of sand and even sewage brought down by the current, causing the east bank of the dredged channel to cave in within a linear distance of about 2,000 feet. The dredging records show that the second, third, and fourth dredge cuts east of the range line have been and the last-named is now being dredged to 14 feet depth of water for the third time.

2. Essexville Bar.—This is a shoal, located between the village of Essexville and the light-houses near the mouth of the river, and was not included in the original estimate, having come into notice within the last two years, during the prevailing extremely low water. The first, last, and only examination (since the lake survey

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in 1858) was made in February, 1892. It shows a navigable channel with 12 feet of water. By excavating 48,000 cubic yards, a channel 14 feet deep and 200 feet wide and 3,000 feet long can be made across this shoal, and steps are being taken to have the improvement commenced under a supplementary contract with McCollum & Lee, using the available balance of the appropriation for Saginaw River for that purpose.

3. Bay City Front.—The last examination was made in 1884; the estimated quantity remaining at that time was 81,600 cubic yards. In 1884 15,416 cubic yards were excavated; and in 1885 24,620 cubic yards, leaving 41,564 cubic yards yet to be removed in order to complete the project according to the above estimate. No complaints having been heard since 1885, it is supposed that the improvement in this locality is permanant and satisfactory, even though it be incomplete.

B. ABOVE BAY CITY.

1. Shoal below Melbourne.—This reach of the river was included in the ice surveys made in February, 1891. It extends from the lower end of the Melbourne lumber docks to the mouth of the Sheboyganning Creek, a distance of nearly 1 mile, the channel being confined between the extensive store booms of the Tittabawassee Boom Company. During the season of 1891 dredging was commenced to make a channel 12 feet deep and 200 feet wide; the total estimate, based on the last survey, was 97,760 cubic yards; of this quantity, 23,623 cubic yards were removed in 1891, leaving 74,137 cubic yards yet to be excavated in order to complete the project.

2. Willow Island.—Since the last examination of this channel was made, in 1884, no dredging has been done, and the estimated quantity of material to be removed to complete project was 35,796 cubic yards. However, as the material through which the channel along Willow Island was dredged consisted principally of clay, the improvement, as far as it has progressed, appears to be permanent and satisfactory, and no complaints have been made as to its insufficiency of available depth for safe navigation.

3. New York Works Bar.—Although considerable dredging had been done in previous years, loaded vessels were frequently delayed during the last two seasons by getting aground on the lower end of this bar. An ice survey was therefore made in January, 1892, for the purpose of learning its present condition. It was found that the channel depth had deteriorated to a considerable extent, owing to deposit of sand in the channel opposite a middle ground, the location of which may be the primary cause of such deposit. To dredge a channel 200 feet wide and 12 feet deep will necessitate the excavation of 79,400 cubic yards, mostly sand, and it appears somewhat doubtful whether this improvement can be made permanent without some further supplementary project involving the construction of a wing dam or otherwise.

4. Zilwaukee Bar.—This is located at the head of Crow Island, and is one of the original obstructions to navigation which were found when (in 1876) the Government first undertook the improvement of Saginaw River above Bay City. A history of this bar, describing in detail all efforts made to permanently remove the obstruction, may be found on page 2147 of the Annual Report of the Chief of Engineers for the year 1885. The last examination and survey was made in February, 1891; the project for the final removal of this bar was then submitted and approved, and during the season of 1891 a channel 12 feet deep and 200 feet wide was made by excavating 32,491 cubic yards of sand and clay. The extension of the wing dam from 900 feet to 1,685 feet was designed as a protection for the adjacent channel, and it is strongly believed that the channel improvement in this locality is permanent. The Zilwaukee Bar may therefore be dropped henceforth from the list of obstructions to navigation in Saginaw River "above Bay City."

5. Carrollton Bar.—The same may also be said and done with this original and notorious obstruction in Saginaw River, a complete history of which is given on page 2143, *et seq.*, of the Annual Report of the Chief of Engineers for 1885. Since that year the projects for improving the Carrollton Channel included the extension of United States revetment on the east side, and the beam wall on the west side, downstream to deep water opposite Charles W. Grant & Co.'s sawmill, together with necessary repairs of the revetment where it was partially destroyed by fire. Only a small amount of dredging was done, as the current of the river, being confined between these structures and thus accelerated, has scoured the channel bottom so as to give a nearly uniform depth of 12 feet and more. The last examination, made in February, 1891, clearly showed the favorable condition of the Carrollton Channel; and it is confidently expected that no more money need be allotted from future appropriations for this reach of the Saginaw River, excepting, perhaps, for necessary expenses in keeping the above-described structures in good repair.

6. Saginaw (east side) river front.—An ice survey of the river channel, extending from the Genesee Avenue Bridge to about one-quarter of a mile below the Flint and Père

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Marquette Railroad Bridge, was made in January, 1892. The map of soundings shows that, while there are small areas with 12 feet depth of water along the trail of the tugs which are used in towing rafts, these areas are not connected and do not furnish a safe and convenient channel for loaded vessels, either those passing down stream with lumber and other products from the sawmills farther up stream or such as are used for bringing coal, limestone, and building materials to the wharves along the river fronts of the city of Saginaw. The river bottom within this reach of the river consists of fine sand and previous efforts in dredging a narrow channel for temporary relief were not attended with success, as the dredge cuts were soon filled up again by the action of passing steamboats, from the apparently inexhaustible supply of soft material adjacent thereto. It is estimated that a channel 12 feet deep and 200 feet wide, can be made by excavating 86,000 cubic yards. Whether such a dredged channel will be permanent is considered very doubtful.

7. Bristol Street Bridge Shoal.—This extends from a point 1,800 feet above to 1,000 feet below the Bristol Street Bridge, which spans the river in the central part of the city of Saginaw. The improvement of this reach of the river was commenced during the season of 1881, as hereinbefore described. An ice survey was made in January, 1892, and the map of the soundings shows that the dredged channel had not deteriorated during the two months intervening. The estimated quantity of material yet to be removed in order to make that channel the required width of 200 feet is 49,300 cubic yards. Its permanency after completion is also an open question.

8. South Saginaw.—During the preliminary examination of the river, made in the fall of 1881, a long reach of river immediately above the Mackinaw Street Bridge at South Saginaw was found to have less than 12 feet depth of water, and the estimated quantity of material to be excavated in order to make a channel 200 feet wide and 12 feet deep, based on that examination of 1881, was 100,000 cubic yards. A subsequent examination of the same locality resulted in an estimate of 70,000 cubic yards. There has been no attempt made to commence the improvement of the river channel in this vicinity, because the biennial appropriations for the improvement of the entire river have been too small to warrant an allotment for this purpose. In the absence of a later examination, I am inclined to retain the larger estimate, *i. e.*, 100,000 cubic yards.

C. WEST CHANNEL ALONG WEST BAY CITY.

Special allotments having been made from two appropriations for improving Saginaw River, viz, $5,000 August 5, 1886, and $15,000 August 11, 1888, these amounts were expended in accordance with a supplementary project for improving the west channel of the Saginaw River, dated April 11, 1887. An ice survey of the three sections of the west channel which were dredged was made in January, 1891. The improvement was found in good preservation. The sum of $10,000 has been estimated as the amount required for completing this special project.

The following schedule is a recapitulation of the estimated quantities required to be removed, based on the present condition of the channel of Saginaw River and giving the amounts necessary to complete the approved project:

No.	Names of shoals.	Estimates.		Dredged since.		Estimates June 30, 1892.		
		Year.	Cubic yards.	Year.	Cubic yards.	Cubic yards.	Price.	Amount.
	A. General improvement:						Cents.	
1	Outer bar	1891	180,000	1891 1892	56,523 28,661	94,816	50	$52,149
2	Essexville	1892	48,000			48,000	35	18,500
3	Bay City	1884	81,600	1884 1885	15,416 24,620	41,564	30	13,716
	Total							84,365
	B. Above Bay City:							
4	Melbourne	1891	97,760	1891	23,623	74,137	40	32,620
5	Willow Island	1884	35,796			35,796	40	15,750
6	New York works	1892	79,400			79,400	40	34,936
7	Zilwaukee	1891	30,000	1891	32,491			
8	Carrollton	1891						
9	Saginaw (east side)	1892	86,000			86,000	40	37,840
10	Bristol street	1892	49,300			49,300	40	21,692
11	South Saginaw	1881	100,000			100,000	40	44,000
	Total							186,838
12	C. West channel along West Bay City							10,000
	Grand total							281,203

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The several amounts in the above schedule include the usual 10 per cent addition for contingencies of superintendence and engineering; yet, in view of the fact that some of the dredged channels are known to deteriorate more or less by the action of the spring freshets, a sum not less than $5,000 should be added annually in computing the estimated amount required to complete the existing project, for the purpose of covering expenses for redredging, necessary examinations and surveys, extraordinary repairs, office expenses, and other incidentals. Therefore the amount required at the close of the fiscal year ending June 30, 1892, for the completion of the existing project is $286,203.

Annexed hereto I beg leave to submit commercial statistics of the Saginaw River, compiled from the eleventh annual review of the Saginaw Board of Trade, for the calendar year 1891.

Very respectfully, your obedient servant,

B. H. MUEHLE,
Assistant Engineer, etc.

Gen. O. M. POE,
Colonel of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Principal products manufactured and shipped from the Saginaw River, Michigan, during the calendar year of 1891.

Articles.	Quantities.	Tons of 2,000 pounds.
Pine lumber ..... feet, B. M..	758, 610, 548	1, 137, 916
Shingles ..... pieces..	222, 607, 250	33, 391
Lath ..... pieces..	153, 807, 800	38, 452
Salt ..... barrels..	1, 774, 844	266, 227
Stoves ..... pieces..	28, 179, 492	14, 090
Headings ..... sets..	1, 639, 417	3, 279
Hardwood and hemlock ..... feet B. M..	67, 897, 600	135, 795
Total	.....	1, 629, 150

These figures were obtained from the Eleventh Annual Review issued by the Saginaw Board of Trade, for the season of 1891. Sufficient tonnage should, however, be added to make the total at least 2,000,000 tons, which includes manufactured lumber, machinery, furniture, and other products of which no records have been kept.

One-half of this tonnage is shipped by water, the other by rail, there being six railroads which compete with the water routes and with each other for the transportation of the products and commerce of the Saginaw Valley.

L L 10.

IMPROVEMENT OF HARBOR OF REFUGE AT SAND BEACH, LAKE HURON, MICHIGAN.

Prior to 1876 vessels, when caught in heavy weather near the dangerous Pointe aux Barques, the southerly headland of the mouth of Saginaw Bay, were compelled to run a distance of 60 miles and find a refuge in St. Clair River. After the subsidence of the storm those upward-bound had to work their way back again.

The project for the construction of a harbor of refuge at Sand Beach was adopted in 1873 and consisted of a breakwater constructed of timber cribs filled with stone, inclosing an area which is to be deepened by dredging.

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The estimate of the probable cost of the improvement was $1,442,500. The sum of $1,155,000 has been appropriated for the work and it was practically completed in 1885 at a cost of about $975,000. Few improvements have resulted in greater benefit to the lake commerce, as is shown by the infrequency of disasters in the vicinity since it became available.

The following statement shows the various contracts in force during the fiscal year ending June 30, 1892, and the present condition of each:

Name of contractor.	Contract for—	Date of contract.	Remarks.
Chauncey E. Mitchell	Hire of dredging plant	June 16, 1890	Closed June 30, 1892.
J. Jenks & Co.	Coal	Mar. 7, 1891	Closed Dec. 31, 1891.
H. D. Edwards & Co.	Ship chandlery	Mar. 26, 1892	Closed Apr. 30, 1892.

Under contract with Chauncey E. Mitchell, dated June 16, 1890, for hire of dredge and outfit by the hour, dredging was continued until the close of the season of 1891 and resumed upon the opening of the season of 1892. The work done consisted in removing shoals in and around the harbor, the material to be excavated being composed of hard clay, bowlders, and sandstone bed rock, very similar in character to grindstone. All the dredging contemplated for the fiscal year was completed, except upon the shoal at the main entrance to the harbor, and six additional dredge cuts were made across this from west to east. The work was stopped on June 30, 1892, because the limit of the contract was reached on that day, and the dredge was then discharged. The amount of material removed during the fiscal year was 25,383 cubic yards, scow measure, in 1,338 hours, 25 minutes, amounting to $10,573.49 at the contract price of $7.90 per hour of work, or nearly 41.7 cents per cubic yard, scow measure, for the material removed. The total number of hours worked under the contract from its beginning was 1,899¼; the total amount of material removed was 31,547 cubic yards, scow measure; the total amount earned by the dredge was $15,004.07, and the average cost for the use of the dredging plant was a little more than 47½ cents per cubic yard, scow measure. The apparent cost per cubic yard for the excavation was increased by the time spent during the first year in removing the wrecked barge *Col. Brackett*, for which there could be no equivalent in cubic yards.

Repairs by a diver were made to the main, west, and south piers during the season of 1891, prior to October 1. During the early part of May, 1892, the diver made a thorough examination of the pier foundations and reported the result in detail. The damage done by the winter's storms was much less than usual, doubtless due to the measures taken last season and to the unusual immunity from severe storms during the year. In this latter respect the winter was quite exceptional, and to this fact, more than to any other, may be attributed the present good condition of the structures and freedom from necessity for extensive and costly repairs.

The diving crew was reorganized June 1, 1892, and from that time until the close of the fiscal year was employed in repairing the damaged places in the foundation, using for this purpose bowlder stone purchased in open market for the low price of $5 per cord.

The west pier now appears to be in a less satisfactory condition than the others, and extensive repairs must soon be made to the portion above water. The timbers are badly decayed, and the whole super-

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structure will have to be rebuilt with timber or replaced by more durable material.

This harbor is so important that a considerable sum should always be at command. A breach made in the breakwater, which could be repaired at comparatively small cost if done at once, is liable, if repairs are delayed, to become a very expensive matter. The original project for the harbor has been practically completed, except the superstructure on the south pier and the dredging, and it is thought that the former will not prove necessary. The dredging, however, though practically completed, as far as the original project is concerned, may be continued with advantage.

The piers were begun in 1873, and work on them has been continued annually since that time. The superstructure, especially that of the west pier, is in a bad condition, and while the frequent repairs and renewals of timber and plank give the whole an appearance of strength and solidity, age and decay have partially or wholly destroyed many interior timbers which can not be removed without tearing down the entire superstructure, and which are not even discovered until a severe storm lays them open for inspection.

There is no doubt, therefore, that the present timber superstructure will continue to suffer more and more each succeeding year, and that the annual cost of the repair will steadily increase. For this reason, the next appropriation, if sufficient in amount, should be expended in beginning the construction of a superstructure of concrete or other permanent material, part of the appropriation to be expended for current repairs, for custody and control of the harbor, and for dredging in and about the harbor, and the following estimates of the amounts that can be profitably expended in the fiscal year ending June 30, 1893, are herewith submitted.

For beginning the construction of a permanent superstructure	$200,000
Current repairs	10,000
Custody and control of the harbor for one year	5,000
Dredging in and about the harbor	15,000
Total	230,000

As the foregoing are estimates for only one year, the entire amount should be appropriated in one sum. The fact should not be lost sight of that the works as originally designed for this harbor, except dredging and possibly the superstructure of the south pier, have been completed. All the expenditures herein proposed, except the dredging, will be entirely outside of the original project, and therefore not chargeable thereto.

As is well known, this harbor has but little local importance, but it is of incalculable benefit to the general commerce of the lakes. The extent to which it is utilized, as shown by the appended tables, makes it well worthy the sum asked for its preservation.

Thirteen hundred and thirty-one vessels, with an aggregate registered tonnage of 475,522.27, entered the harbor for shelter during the fiscal year.

Total expenditures to June 30, 1891	$1,091,812.26
Expended during the fiscal year, exclusive of liabilities outstanding June 30, 1892	14,256.34
Total expenditures to June 30, 1892	1,106,068.60

The work is in the collection district of Huron, Mich. The nearest port of entry is Port Huron. One light-house and three beacons mark the entrance to the harbor.

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Money statement.

July 1, 1891, balance unexpended	$59,673.51
June 30, 1892, amount expended during fiscal year	15,511.88
July 1, 1892, balance unexpended	44,161.63
July 1, 1892, outstanding liabilities	3,778.42
July 1, 1892, balance available	40,383.21
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	190,383.21
Amount that can be profitably expended in fiscal year ending June 30, 1894. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	80,000.00

Appropriations for improving harbor of refuge, Lake Huron, Michigan.

March 3, 1871	$100,000	March 3, 1881	$50,000
June 10, 1872	100,000	August 2, 1882	75,000
March 3, 1873	75,000	July 5, 1884	75,000
June 23, 1874	75,000	August 5, 1886	75,000
March 3, 1875	100,000	August 11, 1888	70,000
August 14, 1876	75,000	September 19, 1890	30,000
June 18, 1878	100,000		
March 3, 1879	75,000	Total	1,150,000
June 14, 1880	75,000		

Abstract of bids for supplies for improving harbor of refuge, Lake Huron, Michigan, received and opened March 14, 1892, in accordance with advertisement dated February 23, 1892.

No.	Name and address of bidder.	Contract for—	Total.
1	J. Jenks & Co., Sand Beach, Mich	Coal	*$425.00

* Recommended for acceptance.

No. I.—*Record of vessels taking shelter in the harbor of refuge, Lake Huron, Michigan, from June 30, 1891, to June 30, 1892.*

Direction of wind at time of entering.	1891.						1892.				Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Apr.	May.	June.	
North:											
Steam	14	15	9	16	1	.....	.....	7	44	6	112
Sail	7	5	1	5	.....	.....	.....	1	11	4	34
Tow	8	3	1	13	2	.....	.....	4	16	4	51
											197
Northwest:											
Steam	13	19	25	63	47	5	.....	2	4	4	182
Sail	3	4	10	3	7	1	.....	1	.....	5	34
Tow	11	9	17	64	29	.....	.....	2	.....	1	133
											349

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No. 1.—Record of vessels taking shelter in the harbor of refuge, Lake Huron, Michigan, from June 30, 1891, to June 30, 1892—Continued.

Direction of wind at time of entering.	1891.						1892.				Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Apr.	May.	June.	
West:											
Steam	2	5	7	18	23	.....	.....	3	7	2	67
Sail	3	.....	3	7	3	.....	.....	1	2	3	22
Tow	.....	6	10	9	9	.....	.....	.....	3	.....	37
											126
Southwest:											
Steam	9	4	16	15	29	15	1	11	14	6	120
Sail	18	10	15	9	10	2	.....	5	14	5	88
Tow	.....	.....	6	3	19	5	.....	13	1	.....	47
											255
South:											
Steam	3	.....	1	5	13	1	.....	.....	.....	2	25
Sail	1	1	3	3	8	.....	.....	.....	1	3	25
Tow	.....	.....	.....	.....	17	1	.....	.....	.....	.....	18
											68
Southeast:											
Steam	7	12	17	10	12	.....	.....	4	19	11	92
Sail	5	14	9	8	2	.....	.....	4	17	7	66
Tow	3	.....	4	5	11	.....	.....	.....	9	5	37
											195
East:											
Steam	1	6	1	.....	.....	1	.....	2	2	1	14
Sail	.....	1	3	.....	.....	.....	.....	.....	5	1	10
Tow	.....	1	1	.....	.....	1	.....	.....	.....	.....	3
											27
Northeast:											
Steam	5	12	7	13	1	3	.....	9	6	7	63
Sail	.....	1	1	5	1	.....	.....	3	1	11	23
Tow	4	2	6	10	.....	.....	.....	5	1	.....	28
											114
Monthly total:											
Steam	54	73	83	140	126	25	1	38	96	39	675
Sail	37	36	45	45	31	3	.....	15	51	39	302
Tow	26	21	45	104	87	7	.....	24	30	10	354
Total	117	130	173	289	244	35	1	77	177	88	1,331

No. 2.—*Classified table of tonnage, by months, entering the harbor of refuge, Sand Beach, Lake Huron, for shelter, from June 30, 1891, to June 30, 1892.*

Months.	Steam.		Sail.		Tow.		Total.	
1891.	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
July	54	17,153.23	37	2,423.58	26	9,892.61	117	29,469.42
August	73	33,270.14	36	1,804.57	21	10,371.35	130	45,446.06
September	83	30,274.95	45	3,170.59	45	23,678.96	173	57,124.50
October	140	74,252.84	45	5,306.19	104	47,761.22	289	127,320.25
November	126	67,435.82	31	5,778.09	87	36,333.26	244	109,547.17
December	25	19,004.28	3	851.19	7	3,368.43	35	23,223.90
1892.								
January	1	980.70	.....	.....	.....	.....	1	980.70
April	38	13,265.65	15	1,313.07	24	7,167.23	77	21,745.95
May	96	27,165.86	51	4,987.99	30	10,184.09	177	42,337.94
June	39	12,924.23	39	2,356.65	10	3,045.80	88	18,326.68
Total	675	295,727.70	302	27,991.92	354	151,802.95	1,331	475,522.57

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No. 3.—*Tonnage of vessels taking shelter in the harbor of refuge, Sand Beach, Lake Huron, Michigan.*

Calendar year.	Steam.	Sail.	Tow.	Total.	Total number of vessels.	Average tonnage.
	Tons.	*Tons.*	*Tons.*	*Tons.*		
1877	63,966	27,699	50,954	142,619	493	289
1878	104,025	39,699	99,282	243,006	781	311
1879	133,080	45,750	100,096	278,926	921	303
1880	158,720	55,630	147,260	361,610	1,317	275
1881	144,645	55,960	127,855	328,460	1,176	279
1882	146,132	26,504	114,067	286,703	1,022	280
1883	177,122	32,713	114,091	323,926	1,139	284
1884	156,518	34,724	122,980	314,222	1,142	275
1885	196,364	29,426	151,607	377,397	1,158	325
1886	196,335	33,790	140,862	370,987	1,304	284
1887	271,327	33,689	153,087	458,103	1,447	317
1888	271,917	39,756	202,191	513,864	1,624	316
1889	289,719	37,922	165,896	493,537	1,512	326
1890	325,852	38,826	169,104	533,783	1,575	339
1891	292,917	27,076	171,067	491,059	1,341	366
Total	2,928,639	559,164	2,030,399	5,518,202	17,952	307

L L 11.

IMPROVEMENT OF BLACK RIVER AT PORT HURON, MICHICAN.

Before improvements were commenced the lower reach of Black River, from its mouth to the Grand Trunk Railroad Bridge, a length of nearly 1½ miles, varied in width from 120 to 150 feet, and had a navigable channel of from 10 to 14 feet in depth, except at a few points where it was obstructed by shoals or bars having only 8½ feet of water over them.

The river and harbor act of August 11, 1888, called for an examination of "Black River at Port Huron, to deepen channel from mouth to Grand Trunk Railroad Bridge to depth of 18 feet." After a preliminary examination of the locality had been made I reported that the river, within the limits indicated, while not worthy of improvement to so great a depth as 18 feet, was worthy of improvement to a depth of 15 feet, and a survey was consequently authorized to obtain data on which to base a project for this latter depth. As a result of this survey an estimate of $55,110 was made on May 9, 1889, for improving the reach of the river in question to a depth of 15 feet.

The river and harbor act of September 19, 1890, appropriated $25,000 for "improving Black River at Port Huron, Mich., to deepen channel from mouth to Grand Trunk Railroad Bridge to depth of 16 feet," 1 foot greater depth than that for which the estimate had been made. A general project for the improvement of the river to the depth named in the appropriation was therefore submitted in January, 1891, and was duly approved. It contemplates excavating a channel 16 feet deep from the mouth of the river to the Grand Trunk Railroad Bridge, and of width varying between 160 and 75 feet, according to locality. On account of the greater depth the estimate for the work was increased to $75,000.

At the beginning of the fiscal year a contract with Chauncey E. Mitchell for dredging was in force, under a project for the expenditure of $25,000 appropriated for the work by the river and harbor act of September 19, 1890. The work proposed to be accomplished was to

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excavate a channel two dredge-cuts wide and 16 feet deep from the mouth of the river upstream as far as the funds available would permit, and if these were more than sufficient to carry the two cuts to the Grand Trunk Railroad Bridge, then to widen the lower reach of the channel until the funds were exhausted, all in furtherance of the general project. This contract has been extended to December 1, 1892.

Dredging has been in progress throughout the fiscal year and is not yet completed. It was stopped for the season on November 28, 1891, and resumed April 16, 1892. On June 30, 1892, a channel 16 feet deep extended from the mouth of the river towards the Grand Trunk Railroad Bridge, the whole length being about 6,200 feet. Its width from the mouth of the river to Military Street Bridge, a distance of about 1,700 feet, was 75 feet, and it was 50 feet wide for the further distance of about 4,500 feet.

	Cubic yards.
Amount of material removed prior to June 30, 1891	18,225
Amount of material removed during fiscal year	73,048
Total amount of excavation to June 30, 1892	91,273

Cost of examination and survey prior to appropriation for improvement	$731.50
Expenditures to June 30, 1891, under appropriation of September 19, 1890	2,399.11
Expenditures and obligations during fiscal year ending June 30, 1892	12,935.38
Total cost to June 30, 1892	16,065.99
Estimated cost of the improvement	75,000.00
Appropriated by act of September 19, 1890	25,000.00
Amount to credit of estimate	50,000.00

Of the balance remaining to the credit of the estimate the sum of $25,000 can be advantageously expended during one fiscal year.

Black River, at Port Huron, is in the collection district of Huron, Mich. The nearest port of entry is Port Huron, through the midst of which the river runs, and the nearest light-house is Fort Gratiot Light, distant about 2 miles.

Money statement.

July 1, 1891, balance unexpended		$23,831.23
June 30, 1892, amount expended during fiscal year		9,456.73
July 1, 1892, balance unexpended		14,374.50
July 1, 1892, outstanding liabilities	$2,309.88	
July 1, 1892, amount covered by uncompleted contracts	12,064.62	
		14,374.50
Amount appropriated by act approved July 13, 1892		10,000.00

Amount (estimated) required for completion of existing project	40,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	25,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriation for improving Black River, Michigan, at Port Huron, etc.

September 19, 1890	$25,000

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COMMERCIAL STATISTICS.

Entered during calendar year, 1891.

Commodities.		Amounts.	Tons.
Lumber	feet, B. M.	16,000,000	37,000
Shingles	pieces	2,908,000	385
Laths	do	1,000,000	100
Cedar posts	do	6,000	125
Coal			13,000
Wood and pulp	cords	7,000	14,500
Salt			180
Stone	cords	700	4,700
Wood	do	5,000	10,000
Bricks	pieces	400,000	9,895
Total			89,885

No shipments were made from the river.

L L 12.

IMPROVEMENT OF MOUTH OF BLACK RIVER, MICHIGAN.

Black River empties into St. Clair River, at Port Huron, Mich. At and below its mouth, extending beyond the middle of St. Clair River, there is a bar, or Middle Ground. Under former appropriations this bar was dredged to a clear depth of 15 feet. The main channel of St. Clair River is found between the Middle Ground and the Canadian shore.

By the deposit of material brought down by the current of Black River the depth on the bar had been reduced an average of about 6 inches, and, in conjunction with a low stage of water, became an impediment to navigation along the front of the city of Port Huron in the vicinity.

In accordance with projects approved in 1889 and 1891 it was proposed to improve the bar by making a series of dredge cuts, of a uniform depth of 16 feet, along the dock front of Port Huron, from the 16-foot curve above to the same curve below the mouth of Black River, the first cut at a distance of about 50 feet from the wharves, and the others to continue the work outward as far as the available funds would permit.

Under the project of 1889 (act of August 11, 1888) the bar was dredged to the full depth of 16 feet, for a width of 300 feet, the amount of material removed being 46,239 cubic yards, scow measurement.

Under the project of 1891 (act of September 19, 1890) a contract dated March 11, 1890, with the Bay City Dredging Company, for dredging, was in force at the beginning of the fiscal year, and work was continued until November 14, 1891, when it ceased on account of the exhaustion of the appropriation. The amount of material removed during the fiscal year was 40,011 cubic yards, scow measurement, and the aggregate under this contract was 57,515 cubic yards. The result was to add 420 feet to the width of the improvement, thus making it 720 feet wide.

The whole amount of material removed under the two projects was 103,754 cubic yards, scow measure. The dredging should be continued

outward for an additional width of 650 feet, and it is estimated that this, together with some redredging, can be done for $20,000, which sum can be advantageously expended during one fiscal year.

Not only the local commerce of Port Huron, but the general commerce of the lakes is interested in this improvement.

Total expenditure to June 30, 1891		$12,868.23
Expended during fiscal year (inclusive of outstanding liabilities)		6,939.05
Total expenditure to June 30, 1892		19,807.28
Appropriation of August 11, 1888	$10,000.00	
Appropriation of September 19, 1890	10,000.00	
		20,000.00
Balance		192.72

The mouth of Black River is in the collection district of Port Huron, Mich. The nearest port of entry is Port Huron. The nearest light-house is Fort Gratiot Light, about 2 miles distant.

Money statement.

July 1, 1891, balance unexpended	$9,259.47
June 30, 1892, amount expended during fiscal year	9,066.75
July 1, 1892, balance unexpended	192.72
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	10,192.72
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	20,000.00

Appropriations for improving Black River, Michigan, at mouth.

June 10, 1872	$15,000.00
August 11, 1888	10,000.00
September 19, 1890	10,000.00
Total	35,000.00

COMMERCIAL STATISTICS.

Season of 1891.	Number of vessels.	Registered tonnage.
Entered	1,156	288,280
Cleared	1,164	310,150
Total	2,320	598,430

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L L 13.

IMPROVEMENT OF ST. CLAIR FLATS CANAL, MICHIGAN.

Before the construction of this canal St. Clair River emptied into Lake St. Clair through seven principal mouths or passes, the one ordinarily used by vessels being known as the South Channel, and having a minimum depth of a little less than 11 feet.

St. Clair Flats Canal was projected in 1866 with a view of obtaining a straight channel 13 feet deep and 300 feet wide across the flats east of the mouth of the South Channel, and the work was finished in 1871.

The channel is bounded on each side by a dike 7,221 feet long, or an aggregate of 14,442 feet, these dikes consisting of timber resting upon piles driven into the original bottom of the shoal, the crib pockets being filled with material dredged from the channel and the cribs backed with dredged material.

To maintain a channel bank a single row of sheet piling was driven along the channel face of the cribs previous to dredging, and the back or lake sides of the dikes were protected from wave-action by shorter sheet piling.

In 1873 the channel was deepened to 16 feet by dredging for a width of 100 feet on each side of the axis of the canal, or a width of 200 feet in all, being thus limited by the fact that the single row of sheet piles, intended for a depth of 13 feet, had not sufficient penetration to admit of dredging to 16 feet for the full width of the canal, and was also insufficient to prevent leakage of the dike filling through it into the channel.

The present approved project for the improvement of the canal contemplates driving a double row of sheet piling to a depth of 26 feet along the channel face of each dike, dredging the area between the dikes to a depth of 20 feet, continuing the channel above and below the canal to the same depth in river and lake, and rebuilding the decayed portions of the timber superstructure. It is considered sufficient to obtain the depth of 18 feet at present, and to postpone obtaining the depth of 20 feet until the general project for a continuous depth of 20 feet along the entire water route shall have reached a more advanced stage. The estimated cost of obtaining these two depths is as follows:

For 18 feet	$365,000.00
For 20 feet	513,559.40

On June 30, 1891, a channel 18 feet in clear depth and 150 feet in width extended from the 18-foot curve in St. Clair River, about 900 feet above the canal, down into the canal for a total length of about 3,890 feet, the dredged channel occupying the east half of the northern part of the canal. A little over 3,000 linear feet of sheet piling remained to be done to complete the revetment, and work was still in progress.

Under contract with Mr. Luther E. Allen, dated November 28, 1890, the time for completion being extended from December 1, 1891, to September 1, 1892, dredging has been in progress during the entire year, except for interruption by the winter, and this work is not yet completed. A total of 186,461 cubic yards, scow measure, has so far been excavated under this contract, of which 142,965 cubic yards were removed during the fiscal year.

Under contract with Messrs. Steiner & Griffin, dated November 28, 1890, the time for completion having been extended from December 1,

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1891, to May 30, 1892, and subsequently to June 30, 1892, revetment construction continued, except for interruption by the winter, until June 16, 1892, when a total of 3,650 linear feet of sheet piling and 90 feet of superstructure had been completed under this contract, of which 3,160 feet of sheet piling and 90 feet of superstructure were constructed during the fiscal year. This completed the new revetment, and the contract was closed.

On June 30, 1892, a channel 18 feet in clear depth extended from the 18-foot curve in St. Clair River, about 900 feet above the canal, for the full width of the canal (about 300 feet) and throughout its entire length, and for a further distance of 2,100 feet below the canal, where its width was gradually increased to 380 feet. A double row of sheet piling had been driven to a depth of 26 feet along the channel face of each dike.

The general project for a continuous depth of 20 feet along the entire water route is not yet in a sufficiently advanced stage to warrant making this depth at St. Clair Flats Canal at present, but the depth of 18 feet is urgently demanded. All through commerce between Lakes Ontario and Erie and Detroit River, on the one hand, and Lakes Huron, Michigan, and Superior on the other, must pass through this canal. This commerce is about the same as that through Detroit River, which for the season of 1891 consisted of 34,251 vessels, having a registered tonnage of 22,160,000. The importance of carrying this work to completion at the earliest possible date, therefore, can readily be understood. The amount necessary to complete the project for attaining the depth of 18 feet and rebuilding the decayed portions of the superstructure is $196,250, and this entire amount can be profitably expended during the fiscal year ending June 30, 1894.

Total expenditure to June 30, 1891 (erroneously reported last year as $707,015.95)*	$696,179.50
Expended during fiscal year (exclusive of outstanding liabilities)	53,581.40
Total expenditure to June 30, 1892	749,760.90

St. Clair Flats Canal is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. Two light-houses stand upon its banks.

Money statement.

July 1, 1891, balance unexpended		$78,981.21
June 30, 1892, amount expended during fiscal year		63,932.11
July 1, 1892, balance unexpended		15,049.10
July 1, 1892, outstanding liabilities	$7,940.88	
July 1, 1892, amount covered by uncompleted contract	3,264.17	
		11,205.05
July 1, 1892, balance available, applicable only to Grosse Point Channel.		3,844.05

Amount (estimated) required for completion of existing project	196,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	196,250.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

* This account was originally made up in 1889 from the best data available at the time. Upon closer investigation during the present year it was found to be erroneous. The error occurred in the earlier years of the work, and the correction is made at this time.

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Appropriations for improving Saint Clair Flats Canal, Michigan.

June 23, 1866	$80,000	June 18, 1878	5,000
March 2, 1867	150,000	March 3, 1879	3,000
July 25, 1868	86,000	June 14, 1880	2,500
April 10, 1869	142,560	August 5, 1886	18,750
July 11, 1870	16,500	August 11, 1888	75,000
March 3, 1871	1,500	September 19, 1890	80,000
June 10, 1872	4,000		
March 3, 1873	100,000	Total	764,810

NOTE.—The appropriation of 1852, $20,000, and 1856, $45,000, are not taken account of for the reason that they did not enter into the improvement of St. Clair Flats Canal, being expended in building a dredge and in dredging the South Pass. From March 3, 1881, the amounts allotted for operating and care of St. Clair Flats Canal are rendered separately.

L L 14.

OPERATING AND CARE OF SAINT CLAIR FLATS CANAL, MICHIGAN.

The canal is in immediate charge of a custodian who reports any violations of canal regulations, and also acts as inspector whenever any work is in progress.

During the spring of 1892 repairs were made to the canal revetments at 11 different places where they had been injured by the striking of vessels. The cost of this work was $571.16.

During the fiscal year ending June 30, 1892, the ordinary current expenses of operating and care of the canal, such as salary of custodian, trimming willows, etc., exclusive of the amount named above, was $1,888.67.

The estimated cost of operating and care of the canal for the fiscal year ending June 30, 1893, is as follows:

Salary of custodian	$1,500
Current repairs and contingencies which can neither be foreseen nor estimated for in detail to include a fair proportion of the expenses of the office of the Superintending Engineer at Detroit	3,500
Total	5,000

All of which is provided for by indefinite appropriation (section 4 of the river and harbor act of June 5, 1884).

Total expenditure to June 30, 1891	$59,253.30
Expended during fiscal year	1,888.67
Total expenditure to June 30, 1892	61,141.97

St. Clair Flats Canal is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. Two light-houses stand upon its banks.

Money statement.

Amount required for fiscal year ending June 30, 1893		$5,000.00
Balance remaining of allotments of preceding year, exclusive of outstanding liabilities	$3,308.33	
Outstanding liabilities	625.00	
		2,683.33
Additional allotment required for fiscal year ending June 30, 1893		2,316.67

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Appropriations for operating and care of Saint Clair Flats Canal, Michigan.

Expended during fiscal year ending June 30—

1882	$8,783.69
1883	5,668.87
1884	2,532.15
1885	4,906.59
1886	9,539.11
1887	1,819.53
1888	1,510.00
1889	20,315.00
1890	2,158.16
1891	2,020.20
1892	1,888.67
Total	63,141.97

Itemized statement of expenditures incurred on account of appropriation for operating and care of canals and other works of navigation indefinite, applied to operating and care of Saint Clair Flats Canal, Michigan, for the fiscal year ending June 30, 1882.

Date.	No. of voucher.	From whom purchased.	Articles.	Amount.
1891.		*Part of first quarter, 1892.*		
Aug. 1	2	Payroll, July, 1891	1 custodian	$125.00
			1 oarsman	50.00
Sept. 1	3	Payroll, August, 1891	1 custodian	125.00
			1 oarsman	50.00
		Second quarter, 1892.		
Oct. 2	1	Payroll, September, 1891	1 custodian	125.00
			1 oarsman	50.00
Nov. 2	2	Payroll, October, 1891	1 custodian	125.00
			1 oarsman	50.00
Dec. 2	3	Payroll, November, 1891	1 custodian	125.00
			1 oarsman	50.00
			2 carpenters, 10 days, at $2 per day	20.00
31	4	Payroll, December, 1891	1 custodian	125.00
			1 laborer, 28 days, at $50 per month	46.67
1892.		*Third quarter, 1892.*		
Jan. 31	1	W. H. Mott, custodian	Services as custodian at St. Clair Flats Canal, Michigan, from January 1 to January 31, 1892 (both days inclusive), being one month.	125.00
Feb. 29	2	W. H. Mott	Services as custodian at St. Clair Flats Canal, Michigan, from February 1 to February 29, 1892 (both days inclusive), being one month.	125.00
Mar. 31	3	do	Services as custodian at St. Clair Flats Canal, Michigan, from March 1 to March 31, 1892 (both days inclusive), being one month.	125.00
		Fourth quarter, 1892.		
May 4	1	Payroll, April, 1892	1 custodian	125.00
June 10	2	Payroll, May, 1892	1 custodian	125.00
		Month of July, 1892.		
July 1	1	Payroll, June, 1892	1 custodian	125.00
			2 sub-inspectors, 24 days, at $90 per month.	72.00
			Total	1,888.67

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L L 15.

IMPROVEMENT OF CLINTON RIVER, MICHIGAN.

In 1870 the channel over the bar at the entrance to this river afforded a depth of only 3½ feet, while the depth in the river for some distance above was 10 feet.

A project for dredging a channel across the bar was approved and carried into effect in 1870. A project for the general improvement of the river from its mouth to the city of Mount Clemens was submitted in 1880 and renewed and approved in 1889. It contemplates a channel 8 feet deep and of navigable width for the entire distance of about 8½ miles from the mouth of the river to Mount Clemens. Involved in this was the closing of a gap opposite Mount Clemens and of Catfish (or Blind) Channel; also closing the main channel at, and making a straight cut across, Shoemakers Bend, constructing a revetment on the north side of the mouth from the shore to the requisite depth in Lake St. Clair, and dredging wherever necessary to attain the desired depth, the estimated cost of the improvement being $32,926.

Prior to the beginning of the fiscal year the work at Shoemakers Bend had been completed; the gap opposite Mount Clemens had been closed, and some dredging had been done at the mouth of the river and at various shoals between there and Mount Clemens.

At the beginning of the fiscal year the only contract in force was one with Mr. George Lockerbie, dated February 13, 1891, approved March 8, 1891, for dredging. Under this contract operations had been begun May 1, 1891, and were continued until October 4, 1891, when the funds were exhausted and the work ceased.

The result was a channel 8 feet deep and 75 feet wide or more, from the mouth of the river to the bridge at Mount Clemens. Although the channel can not be considered permanent, yet no complaint of its deterioration has reached this office up to the date of this report.

	Cubic yards.
The volume of material removed during the fiscal year was	23,374
And the total volume under this contract was	38,401
Total expenditures to June 30, 1891	$45,405.06
Expended during fiscal year	6,006.54
Total expenditures to June 30, 1892	51,411.60

Eight thousand five hundred and sixty-four dollars and fourteen cents still remain to be appropriated to complete the improvement in accordance with the existing project, and in view of the relief already afforded the river is worthy of the additional appropriation. This amount can be profitably expended during the fiscal year ending June 30, 1893.

But the good effect of the dredging already done is liable to be destroyed by deposits of material brought down by annual freshets in the river, for which reason the foregoing estimate can only be considered as approximate for the fiscal year, and is probably too low if the work be deferred beyond that time.

The proposed navigable depth having been once obtained, no charges for maintenance should be made against it. The balance named is intended only for the construction of the revetment on the north side of the river at the mouth. The good effect of the dredging already done is liable to be impaired by deposits of material brought down by annual

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freshets in the river, and the cost of restoring the depth should be chargeable to future estimates and appropriations thereunder.

Clinton River is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. The nearest light-houses are those at St. Clair Flats.

Money statement.

July 1, 1891, balance unexpended	$7,971.49
June 30, 1892, amount expended during fiscal year	7,869.97
July 1, 1892, balance unexpended	101.52
Amount appropriated by act approved July 13, 1892	8,564.00
Amount available for fiscal year ending June 30, 1893	8,665.52

Appropriations for improving Clinton River, Michigan.

August 30, 1852	$5,000	August 5, 1886	$6,000
July 11, 1870	5,000	August 11, 1888	10,000
March 3, 1871	1,500	September 19, 1890	10,000
March 3, 1881	8,000		
August 2, 1882	6,000	Total	51,500

COMMERCIAL STATISTICS.

Articles entered and cleared during the season of 1891.

Articles entered.	Amount.	Tons.	Articles cleared.	Amount.	Tons.
Lumber ..... feet, B. M.	7,200,000	14,000	Flour ..... barrels	1,800	180
Coal		10,500	Oats ..... bushels	5,000	188
Salt ..... barrels	800	110	Staves ..... feet, B. M.	6,000,000	3,000
Cement ..... do	500	50	Headings ..... do	6,000,000	3,000
Stone ..... cords	1,600	9,000			
Iron		650	Total		6,368
Logs ..... feet, B. M.	8,000,000	16,000			
Shingles ..... do	4,000,000	500			
Laths ..... do	6,000,000	520			
Heading bolts ..... cords	5,000	10,000			
Total		61,330			

Number of vessels cleared during the season of 1891.

Steam	298
Sail	102

L L 16.

IMPROVEMENT OF GROSSE POINTE CHANNEL, MICHIGAN.

Between the lower end of St. Clair Flats and the deep water of Detroit River, the only known obstruction to navigation is the large shoal off Grosse Pointe, known as Grosse Pointe Flats. At ordinary stages of water vessels drawing 16 feet can cross this obstruction, but

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when the water is as low as it has been during the last few years, vessels drawing more than 15 feet can pass only with great care and difficulty.

The river and harbor act of August 11, 1888, appropriated $75,000 for "improving St. Clair Flats Ship Canal, * * * all or any portion of which may, in the discretion of the engineer, be expended in dredging Grosse Pointe Channel." Five thousand dollars was consequently reserved from this appropriation for the removal of any small and well-defined obstruction that might be found at Grosse Pointe, as well as for making such surveys as might be necessary before making a definite project. A small shoal was removed in July, 1889, but no more such obstructions have since been found.

As the improvement of other connecting channels of the Great Lakes begins to approach the 20-foot depth, which it is recognized that they should ultimately have, the annoyance to shipping at Grosse Pointe Flats must increase, and the necessity for a channel at this point is urgent. The number of vessels annually crossing these flats is enormous, and to insure a thoroughly satisfactory result a channel 800 feet wide and nearly 5½ miles long should be dredged. The material to be excavated consists of sand, gravel, and clay, and the approximate estimate of the cost of this work is as follows:

Dredging 2,889,472 cubic yards, at 30 cents	$869,841.60
Add 10 per cent for contingencies	86,984.16
Total	956,825.76

In an estimate submitted February 10, 1888, I placed the cost of a channel 19½ feet deep at $553,000, but remarked that to "gain an additional half foot would materially increase the cost." That estimate was based upon a price of 20 cents per cubic yard for dredging. For a channel 20 feet in depth the length of the channel is increased nearly 2 miles, over which the work would be merely "scraping," and therefore disproportionately costly.

But the full depth of 20 feet should be obtained at whatever cost. The commerce which passes this point already exceeds 20,000,000 tons annually, and steps can not be taken too soon for its accommodation.

To accomplish valuable results a large appropriation will be required at first, and unless this be granted the results will be unsatisfactory, and the eventual cost will be greatly increased. With $300,000 available, a narrow channel of the proposed depth can be opened, and will afford immediate though insufficient relief. Its width can subsequently be increased to such an extent as may be necessary.

This improvement is both necessary and urgent, and will benefit nearly the entire commerce of the lakes.

Grosse Pointe Flats are in the collection district of Detroit, Mich. Windmill Point light-house and range lights are in close vicinity.

Money statement.

July 1, 1891, balance unexpended	$3,844.05
July 1, 1892, balance unexpended	3,844.05
Amount (estimated) required for completion of existing project	956,825.76
Amount that can be profitably expended in fiscal year ending June 30, 1894	300,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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L L 17.

IMPROVEMENT OF ROUGE RIVER, MICHIGAN.

Before improvements were begun Rouge River had a channel of 11 feet over the bar at its mouth, and from 10 to 17 feet thence to the bridge of the St. Louis and Wabash Railroad, a distance of nearly 15,000 feet. In earlier days vessels had ascended it to Dearborn, a distance of about 15 miles.

The approved project for improvement contemplates dredging the river to a depth of 16 feet and width of 240 feet at the mouth, gradually narrowing to 100 feet at a distance of about 1,150 feet above, and then continuing this width to the bridge of the St. Louis and Wabash Railroad.

On June 30, 1891, the dredged channel was 16 feet deep, 240 feet wide at the mouth, gradually narrowing to 100 feet at a distance of 1,150 feet above; thence to the Michigan Central Railroad bridge, an additional distance of about 11,500 feet, it averaged 70 feet in width, being wider at the curves. The total length of the dredged channel was about 12,650 feet.

No funds were available during any part of the fiscal year ending June 30, 1892, for which reason no work was done, and some shoaling has taken place in portions of the channel already dredged.

To complete the improvement in accordance with the original estimate will require the sum of $11,690.39, that being the difference between the original estimate and the aggregate of the sums thus far appropriated. In view of the increasing number of manufacturing establishments along its banks, and its availability as a winter harbor for vessels, the river is well worthy of the additional appropriation necessary to complete the project for its improvement. The whole amount can be profitably expended in one fiscal year.

Amount of original estimate		$31,690.39
Amount expended to June 30, 1892	$20,483.28	
Less cost of surveys and examinations prior to making the estimate	616.45	
Amount actually expended upon improvement		19,866.83
Balance to credit of estimate		11,823.56
Balance on hand		133.17
Amount to be appropriated		11,690.39

This work is in the collection district of Detroit, Mich. The nearest light-house is Grassy Island, and the nearest fort is Fort Wayne, each of which is in sight from the work.

Money statement.

July 1, 1891, balance unexpended	133.17
July 1, 1892, balance unexpended	133.17
Amount appropriated by act approved July 13, 1892	11,690.00
Amount available for fiscal year ending June 30, 1893	11,823.17

Appropriations for improving Rouge River, Michigan.

August 11, 1888	$10,000
September 19, 1890	10,000
Total	20,000

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COMMERCIAL STATISTICS.

Commercial statistics have not been obtained for the calendar year 1891, but they were practically the same as those reported in the preceding Annual Report for 1890, wherein they were stated in detail. The freight tonnage for 1890 was 311,000 tons.

L L 18.

IMPROVEMENT OF DETROIT RIVER, MICHIGAN.

Originally the channel at Limekiln Crossing, Detroit River, could not be depended upon for more than 13 feet of water, the ordinary depth being much affected by the direction of the wind. As originally projected in 1874 the improvement at this point was to consist of a curved channel 300 feet wide, with a uniform depth of 20 feet, and the original estimate was based upon this project.

In 1883 it was wisely determined to so modify the project as to secure a straight channel, the least width of which should be 300 feet, with a somewhat greater width at each end, utilizing the work already done.

In 1886 this was further modified to the end that the width of the channel should be increased to 400 feet by removing an additional 100 feet from the western (American) side; and in 1888 a further additional width of 40 feet on the western side was authorized, as the lowest bid under the final appropriation was so low that the money in hand would pay for the increased excavation.

The estimated cost of a 400-foot channel was $1,374,500. The total amount expended up to June 30, 1891, was $702,122.04, and the result has been a channel 440 feet in width, thus accomplishing one-tenth more work than was estimated for at a cost of but little more than half the estimate. Gratifying as this is, the benefit to commerce is far beyond the amount of the original estimate, and since the excavation is through rock the improvement will be permanent.

The only work in progress during the fiscal year was the preparation of a map of the water front of Detroit River, from it head, at Windmill Point, to a point about 2 miles below the River Rouge, a total distance of about 13 miles. For this purpose the total sum expended to June 30, 1892, was $64.48.

Water-gauge observations were made during the months of May and June, 1892, at the light-house depot, Detroit, and at Windmill Point Light-House. Their cost is included in the above statement of expenditures.

Total expenditure to June 30, 1891	$702,122.04
Expended during fiscal year	64.48
Total expenditure to June 30, 1892	702,186.52

The project for Limekiln Crossing having been completed, no further estimate is submitted for work at that point. The extreme low water of the last few years, however, has caused vessels to strike on a number of shoals in different parts of the river, whose existence had not previously been known; and, in view of the magnitude of the commerce affected, all such shoals should be removed as soon as possible. As no detailed information on this subject is at hand, an accurate estimate of the cost of this work can not be made, but $50,000 would probably suf-

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fice for the removal of the more serious of the shoals between the city of Detroit and Lake Erie, and an estimate of that amount is therefore submitted and strongly recommended.

The work is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. The nearest United States light-houses are Mammy Judy and the range lights at the head of Grosse Isle, about 5 miles distant.

Money statement.

July 1, 1891, balance unexpended	$988.37
June 30, 1892, amount expended during fiscal year	64.48
July 1, 1892, balance unexpended	923.89
Amount appropriated by act approved July 13, 1892	30,000.00
Amount available for fiscal year ending June 30, 1893	30,923.89
Amount (estimated) required for completion of existing project	20,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	20,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriations for improving Detroit River, Michigan.

June 23, 1874	$25,000	July 5, 1884	$200.000
June 18, 1878	100,000	August 5, 1886	37,500
March 3, 1879	50,000	August 11, 1888	130,500
June 14, 1880	50,000		
March 3, 1881	50,000	Total	703,000
August 2, 1882	60,000		

COMMERCIAL STATISTICS.

Commerce of Detroit River during the season of 1891, comprising staples only and only such as cleared from United States ports.

Commodities.	Amounts.	Tons.	Commodities.	Amounts.	Tons.
Iron ore and finished iron		6,855,097	Stone		214,226
Coal		6,335,841	Provisions ....hhds..	69,000	12,075
Wheat .....bushels..	79,184,912	2,363,180	Merchandise ...pkgs..	6,648,296	1,800,000
Flour .....barrels..	9,847,343	984,734	Salt .....barrels..	408,361	168,060
Corn .....bushels..	40,288,760	1,151,167	Lumber ...feet, B. M..	1,122,683,000	2,245,366
Oats .....do....	19,403,828	336,396	Laths .....pieces..	22,462,000	6,515
Barley .....do....	12,193,053	292,633	Shingles .....do....	82,462,000	22,000
Flaxseed .....do....	8,665,303	236,295	Silver ore		1,731
Malt .....do....	73,000	1,460	Cement .....barrels..	692,956	99,443
Oil cake .....sacks..	24,000	2,400	Telegraph poles.pieces	51,639	12,000
Copper ore		69,000	Total		23,209,619

Number of vessels, 34,251; registered tonnage, 22,160,000, exclusive of Canadian vessels. If the latter could be included, and the list of commodities made to include all that were carried, whether cleared from a custom-house or not, the total would be much greater.

Total number of vessels and tonnage cleared from all the collection districts on the chain of lakes.

Vessels	55,896
Registered tonnage	32,483,444

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Number of loaded cars that crossed Detroit River during 1891.

East bound	199,173
West bound	120,956
Total	320,129
Tonnage at an average of 12 tons per car	3,841,548
Tonnage at an average of 15 tons per car	4,801,935

L L 19.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Wreck of scow Hannah Moore.—The unladen wooden scow *Hannah Moore* became water-logged and sunk in St. Clair River on July 3, 1891. She lay off Port Huron, Mich., in about 16 feet of water, nearly at right angles to the channel, on her beam ends, her two masts pointing upstream. She was about 450 feet from the Flint and Pere Marquette Railroad Dock, and 1,250 feet below Black River. Her dimensions were approximately as follows: Gross tonnage, 74.23; length, 88 feet; breadth 20 feet; depth, 6 feet 4 inches. She was built in 1868, at St. Clair, Mich., and hailed from Detroit, Mich.

When it became apparent that the owner of the scow did not propose to remove her, a project for her removal at an estimated cost of $1,000, accompanied by the necessary specifications, was submitted to the Chief of Engineers. This project having been approved, the thirty days' notice required by law was published on August 22, 1891, and specifications were issued.

Proposals for removing the wreck were opened on September 21, 1891, and on September 28, 1891, a contract was duly entered into with the lowest bidder, Mr. Chauncey E. Mitchell, for the lump sum of $880.

The work of removal was begun October 15. The scow was broken into two pieces by dynamite, and on October 21 and 23 the two portions were raised and towed to a point near the shore, about 2 miles below Black River. On November 9 all the remaining portions of the wreck were removed satisfactorily, and on November 16 the contract was closed. The total cost to the Government, including superintendence, printing, advertising, etc., was $902.10. No articles of value were recovered.

This work was in the collection district of Huron, Mich. The nearest port of entry was Port Huron, and the nearest light-house was Fort Gratiot Light, at the head of St. Clair River.

Abstract of bids for the removal of the wreck of the scow Hannah Moore from the St. Clair River, opposite the Flint and Pere Marquette Railroad Dock, Port Huron, Mich., received and opened on September 20, 1891, in accordance with advertisement dated August 22, 1891.

No.	Name and address of bidder.	Price.	Remarks.
1	Chauncey E. Mitchell, Detroit, Mich.*	$880	Will use dynamite. Dredge and lighters to be used when wreck will not float, after blasting.*
2	Enoch Townsend, Somers Point, N. J.	980	Remove said vessel by dynamite, and pieces if necessary will lighter.
3	Elijah Dunbar, Detroit, Mich.	1,490	Will use dynamite to break the vessel in pieces, and land same on bank of river with tug.

* Recommended for acceptance.

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APPENDIX M M.

IMPROVEMENT OF RIVERS AND HARBORS ON LAKE ERIE WEST OF ERIE, PENNSYLVANIA.

REPORT OF LIEUTENANT-COLONEL JARED A. SMITH, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Monroe Harbor, Michigan.
2. Toledo Harbor, Ohio.
3. Port Clinton Harbor, Ohio.
4. Sandusky City Harbor, Ohio.
5. Sandusky River, Ohio.
6. Huron Harbor, Ohio.
7. Vermillion Harbor, Ohio.
8. Black River Harbor, Ohio.
9. Cleveland Harbor, Ohio.
10. Fairport Harbor, Ohio.
11. Ashtabula Harbor, Ohio.
12. Removing sunken vessels or craft obstructing or endangering navigation.

EXAMINATIONS AND SURVEYS.

13. Grand River, Ohio, between Richmond and the mouth.
14. Conneaut Harbor, Ohio.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, July 9, 1892.

GENERAL: I have the honor to transmit herewith, in duplicate, annual reports for the year ending June 30, 1892, upon the improvement of rivers and harbors in my charge.

Very respectfully, your obedient servant,

JARED A. SMITH.
Lieutenant-Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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M M 1.

IMPROVEMENT OF MONROE HARBOR, MICHIGAN.

This improvement was commenced in the year 1835, at which time the Raisin River was considered an important stream, and Monroe was a place of some prominence. The plan of improvement consisted in straightening the river and making direct connection with Lake Erie by a canal 4,000 feet long and 100 feet wide, through a sand peninsula.

A description in detail of the earlier operations heretofore carried on for the improvement of this harbor will be found in Annual Reports of 1880 and 1881.

Some minor repairs to the piers and revetment of canal were made in the fiscal year ending June 30, 1891, but nothing has been done during the last fiscal year, and the project for repairs remains untouched.

A project for a general repair of the piers and revetment of canal was adopted in 1886, the cost at that time being estimated at $20,000. No general repairs have been undertaken owing to lack of funds for such a purpose. Of course the condition of the superstructure of piers and the canal revetment is constantly becoming worse. The amount estimated as necessary for the general repairs in 1891 was $26,000. The estimate appears to have been a general one only, as it is not easy to determine in advance the exact extent to which the work must be renewed.

As the officer in charge of the work has had no opportunity to make a critical examination of the situation, the last estimate is here repeated.

The annual report of last year gave the least depths of water for June, 1890, as 9 feet to lower docks and thence to upper docks as 8.5 feet. No examination for channel depths has been made since the date mentioned.

The following is a statement of the amount and date of all appropriations for this improvement:

February 24, 1835	$30,000.00	August 14, 1876	$5,000.00
July 2, 1836	15,000.00	June 18, 1878	2,500.00
March 3, 1837	30,000.00	March 3, 1879	2,000.00
July 7, 1838	15,000.00	June 14, 1880	2,000.00
June 11, 1844	20,000.00	March 3, 1881	1,000.00
August 30, 1852	14,000.00	August 2, 1882	1,000.00
June 23, 1866	31,015.27	August 5, 1886	2,000.00
June 10, 1872	10,000.00	August 11, 1888	5,000.00
March 3, 1873	15,000.00	September 19, 1890	5,000.00
June 23, 1874	10,000.00		
March 3, 1875	10,000.00	Total	225,515.27

The commercial statistics are not sufficiently reliable to make definite comparisons from year to year.

Apparently the tonnage for last fiscal year was about 25 per cent less than in the year previous. The principal imports were telegraph poles and the exports a small amount of fish and grapes. These freights are not of a kind to promise a great increase in the future.

The harbor of Monroe is in the collection district of Detroit, Mich. There is a light-house on the outer end of the west pier.

No new lines of transportation have been established in the last fiscal year.

Money statement.

Amount appropriated by act approved July 13, 1892	$10,000.00
Amount (estimated) required for completion of existing project	16,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	16,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Monroe Harbor, Michigan, were compiled from information furnished by the collector of customs and others:

Imports, telegraph poles	tons	18,000
Exports, fish and grapes	do	22
Vessels entering		83
Vessels departing		84
Tonnage not known.		
Total tonnage for 1891 (estimated)		20,000
Tonnage given in last annual report		27,000

The draft of the largest vessel using harbor is 12 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

No new lines of transportation have been established during the year.

M M 2.

IMPROVEMENT OF TOLEDO HARBOR, OHIO.

The city and harbor of Toledo, Ohio, are near the mouth of the Maumee River. The harbor occupies some distance on the river, and the middle part is about 5 miles from the mouth, where it empties into Maumee Bay. From the mouth of the river to 17 feet depth of water in the lake is a little more than 7 miles.

A history of the earlier operations carried on in past years for the improvement of this harbor will be found in the Annual Reports of 1880, 1881, and 1883.

The project for the "old channel" has been amended from time to time since 1866. The latest plan provides for a channel 200 feet wide on the bottom and 16 feet deep through Maumee Bay to Lake Erie.

A considerable part of the cost is due to the deposits of silt from the river and the filling caused by seas in the bay.

The old channel is now about 100 feet wide on the bottom and 260 feet in the bends, with a least depth of 15.6 at the mean level of the lake. It has been obtained by dredging in a long course of years, with a total expenditure to June 30, 1892, amounting to $724,332.61.

A part of the old channel is now included in the straight channel through Maumee Bay to deep water of Lake Erie.

The act of July 5, 1884, appropriated $25,000 to commence the work of making a straight channel for the Maumee River from its mouth to Lake Erie, and the act of August 5, 1886, provided for continuing the improvement "by a straight channel along such line as may be approved by the Secretary of War."

A project for the work was approved by the Secretary of War April 27, 1887.

The project consisted in dredging a straight channel through Maumee Bay, 200 feet wide at the bottom and 17 feet deep, referred to the mean level of the lake. The line was so located as to utilize the old channel as far as possible. The estimated cost of the work was $1,875,000. The amount expended upon this project to June 30, 1891, was $286,470.55. Total expense to June 30, 1892, including liabilities, $471,707.

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OPERATIONS IN LAST FISCAL YEAR—"OLD CHANNEL."

In the summer of 1891 several shoal spots were dredged in the old channel, the amount of material removed being 20,356 cubic yards. This dredging removed the shoal places, and gave a clear channel of 15.6 feet.

The work was done under the contract with Messrs. L. P. & J. A. Smith.

Expense incurred during the fiscal year has been $4,900.03.

The new and direct channel is now wider and better than the old one, which has several angles, so that it does not seem advisable to incur any further expense upon the old channel project.

STRAIGHT CHANNEL IMPROVEMENT.

Dredging was continued from July 1, 1891, to June 7, 1892, save from December 1 to April 30, inclusive, when it was suspended for the winter.

The amount dredged during the fiscal year is as follows:

	Cubic yards.
Under contract with James Rooney	165,138
Under contract with L. P. and J. A. Smith	438,967
Total	604,105
Amount done by James Rooney under his contract is	249,518
Amount dredged by L. P. and J. A. Smith	471,182
Total under the contract with L. P. and J. A. Smith	548,599

As a result of this dredging the channel is now open to navigation with a depth exceeding 16 feet throughout, and a width of 200 feet on the botton, save in one section of 2,400 feet in the Lake subdivision, where it is but 175 feet wide, and 1,300 feet of Turnout subdivision, where the width is but 170 feet.

It should be observed that the surface level of the lake is very variable, and there seems to have been more than one plane to which soundings in different years have been referred.

For further details of work during the fiscal year, I refer to the report of Lieut. William V. Judson, Corps of Engineers, which is appended as part of this report.

It will be noticed that the channel is not 17 feet deep as has been planned. This is primarily due to the fact that the deepest dredging has been limited to a depth of 17 feet, and it is practically impossible to obtain a perfectly uniform depth by dredging. As a second reason for less depth, there has been a constant deposition of material in the dredged channel.

Apparently the greater portion of the fill in the channel is from the soft mud brought down by the river. This mud is deposited over the entire area of Maumee Bay and naturally fills the channel both by direct deposit and by its movement of material in the bay from heavy seas.

Lieut. Judson gives the present average depth in the straight channel as 15.6 feet, referred to the mean level of the lake using the years 1860 to 1875.

Practically, therefore, the channel lacks one and a half feet of the depth of 17 feet required by the project.

Under my instructions an examination of the channel was made in the months of May and June, 1892. The examination was made by Lieut. Judson, and the charts have been plotted and sections have been

drawn, showing the fill since dredging. Copies of these sections and a small map of Maumee River and Bay are forwarded to accompany this report, and I invite attention to Lieut. Judson's discussion of the subject.

The fill in the channel from sliding in of the banks of the cut seems to be small, but it will be observed that the fill from all causes in two seasons is a little more than eight-tenths of a foot.

It is evident that the dredged channel through Maumee Bay can not be maintained by natural or ordinary conditions.

The alternative is then presented of permitting the channel to fill or of incurring considerable expense for its preservation. It is obvious that the method which offers most of certainty in maintaining the channel is by dredging as necessities may require, and it is my opinion that the dredging can be done most promptly when needed and most satisfactorily and economically at all times with a dredge and scows owned by the United States and operated by hired labor. I believe that one good dredge, with the necessary scows, would be capable of removing all the material which may be required for maintenance of the channel, with the services of a tug, which can probably be hired to best advantage as it may be needed.

The project for this channel left the question of its protection and maintenance open for determination after observation and experience.

A mere revetment to retain the sides of the cut, whether by a low crib work, by piling, or by other means, would be of little or no value, for it would neither prevent the sedimentary deposit nor the movement of mud and sand under the action of the seas.

Whether any system of piers or dikes, submerged or otherwise, will be sufficient to prevent the filling of the channel is doubtful, unless they be so constructed as to confine the river at its high stages sufficiently to maintain a strong current entirely across Maumee Bay to the lake.

Such a system would be attended with many disadvantages in addition to the great cost. It would bring great inconvenience to many small vessels and boats of light draft which navigate the bay, and the silt which is now deposited over all of Maumee Bay would be deposited near the end of the dikes, and sooner or later make further extension necessary.

A part of the channel in the lake subdivision was cut through a sand bar, where the conditions would indicate the probabillty of a more rapid fill than at other places under the action of the seas. It may be well, therefore, to protect the channel over this bar by dikes, entirely submerged at first, as an experiment. The tops should be so arranged as to provide against injury from ice.

The dikes should be placed at considerable distance from the dredged channel. In determining that distance, the régime of the river should be considered. In other words, the distance between the dikes should be the same as would be used if the river were to be conducted between them.

So long as the dikes are to be used only to protect the channel from filling, due to the action of the waves, probably the cheapest and best type of construction may be a compact dump of stone upon mattresses of brush. These would break up the seas which wash across the channel, and would permit any material washed over them to settle on the inside before the channel is reached.

Besides the deposit in the channel, there now remains to be dredged the part of Turn-out Division on the south side of the light-house cribs

in addition to amount required to complete the width at place before mentioned.

No revision of former estimate has been made.

The estimate for completion of project is the same as was submitted in last annual report.

The following is a list of the appropriations made for the old channel from 1866 to present time:

June 23, 1866	$20,000.00	March 3, 1879	$20,000.00
March 2, 1867	20,000.00	June 14, 1880	30,000.00
April 10, 1869	29,700.00	March 3, 1881	40,000.00
July 11, 1870	50,000.00	August 2, 1882	50,000.00
March 3, 1871	50,000.00	July 5, 1884	20,000.00
June 10, 1872	15,000.00	August 5, 1886 (see note	9,632.61
March 3, 1873	100,000.00	August 11, 1888	5,000.00
June 23, 1874	75,000.00	September 19, 1890	5,000.00
March 3, 1875	75,000.00		
August 14, 1876	60,000.00	Total	724,332.61
June 18, 1878	50.000.00		

Appropriations have been made for straight channel as follows, viz:

July 5, 1884	$25,000.00
Deduct amount appropriated for old channel (see note)	9,632.61
	15,367.39
August 5, 1886	112,500.00
August 11, 1888	150,000.00
September 19, 1890	200,000.00
Total	477,867.39

NOTE.—By act of August 5, 1886, the balance then available of the $25,000 appropriated July 5, 1884, for straight channel, was made available for clearing the old channel.

Toledo is in the collection district of Miami. There is a fixed white light of the fourth order on Turtle Island, and three sets of range lights for parts of the channel.

The tonnage of Toledo Harbor, as furnished for 1891, shows a considerable increase over previous years.

Money statements.

OLD CHANNEL.

July 1, 1891, balance unexpended	$4,900.03
June 30, 1892, amount expended during fiscal year	4,423.66
July 1, 1892, balance unexpended	476.37
July 1, 1892, outstanding liabilities	476.37

STRAIGHT CHANNEL.

July 1, 1891, balance unexpended	191,682.54
June 30, 1892, amount expended during fiscal year	176,224.04
July 1, 1892, balance unexpended	15,458.50
July 1, 1892, outstanding liabilities	9,905.89
July 1, 1892, balance available	5,552.61
Amount appropriated by act approved July 13, 1892	200,000.00
Amount available for fiscal year ending June 30, 1893	205,552.61
Amount (estimated) required for completion of existing project	1,200,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	400,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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REPORT OF LIEUTENANT W. V. JUDSON, CORPS OF ENGINEERS.

TOLEDO, OHIO, *June 30, 1892.*

SIR: I have the honor to submit the following report upon operations at this harbor during the fiscal year ending June 30, 1892:

To make clearer what is to follow, I would first explain that the straight channel through Maumee Bay diverges from the old channel at a point near the mouth of the Maumee River. From this point to the 17-foot contour of Lake Erie it is 40,270 feet by the line of the channel. Between the river mouth and the "Black Can" lies the inner section, 12,670 feet in length. Between the "Black Can" and a point 1,000 feet southwest of the main crib light lies the middle section, 10,600 feet in length. From the last-named point to a point 2,400 feet beyond (*i. e.*, northeast of) the main crib light lies the turn-out subdivision, 3,400 feet in length. Beyond the turn-out subdivision, and extending 5,600 feet toward the lake, lies the crib subdivision, and from the outer end of the crib subdivision to the 17-foot contour of the lake stretches the lake subdivision, 8,000 feet in length.

The above-mentioned divisions of the straight channel are mentioned in reports and contracts for the past three years. At the beginning of the fiscal year dredging was being done under two contracts, one with James Rooney, and one with L. P. & J. A. Smith.

Rooney contract.—Two dredges worked steadily upon this contract from July 1 until October 9, 1891, when the work of the contractor was completed. During this time 165,138 cubic yards (scow measurement) were removed from the crib subdivision, completing the excavation within the limits to a least depth of 16.4 feet; the average depth being 16.9 feet.

Smith contract.—Four dredges worked steadily upon this contract from July 1 to November 30, 1891, and these dredges resumed operations May 1, 1892, and worked continuously thereafter until the completion of the contract, June 7, 1892.

In the angle between the old channel and the new, and at the inner end of the latter, was situated a clay bank, which formerly deflected the water descending the Maumee River into the old channel. This clay bank constituted the river division, and from it was removed 111,967 cubic yards, whereby the approach to the straight channel has been widened, promoting ease of navigation, and tending to introduce the river current into the straight channel for purposes of scour. The least depth in this division at completion of dredging was 16.2 feet, with an average depth of 16.8 feet.

From the turn-out subdivision there was removed 106,640 cubic yards. About 1,300 feet of this subdivision is parallel to a pile-protection work that embraces the main and east crib lights in Maumee Bay, and occupies a space 80 feet wide in the center of the straight channel. The north side of this pile work was chosen for dredging, and at this locality the channel has a width of 170 feet, measured from the pile work.

This turn-out has slanting approaches to the straight channel at either end each about 800 feet long. The remainder of the turn-out subdivision is uniform in width with the rest of the straight channel, and was excavated to a least depth of 16.4 feet; the average depth being about 16.8 feet.

From the lake subdivision there was removed 232,327 cubic yards. This yielded a least depth of about 16.4 feet with an average of 16.8 feet, but the full width of 200 feet was not obtained throughout; 2,400 linear feet of this subdivision is but 175 feet wide.

From the old channel there was removed 20,356 cubic yards. Several shoal spots were deepened and the channel was made wider at the elbows. The result was a channel of 15.6 feet minimum depth throughout, the width varying from 100 feet in straight reaches to 260 feet at the turning points.

Pile-protection work.—The main and east crib lights of the Maumee Bay range are situated in the axis of the channel. To prevent vessels from colliding with these, a pile-protection work was in progress at the beginning of the fiscal year. Repeated extensions of time were granted the contractor, who was not prepared to prosecute the work rapidly in the face of the serious difficulties that were consequent upon the exposed location of the work. The work was finally satisfactorily completed December 1, 1891. The crib lights are about 1,080 feet apart. Two rows of piles, each 40 feet from the axis of the channel and parallel thereto, inclose the interval between the range lights, and prevent vessels from getting between them. At either end the pile work is extended to an apex reaching 170 feet beyond the cribs. In bulkheads, at the extreme apices stone and brush have been deposited to the water line. About seven feet of stone and brush have also been deposited about each crib to maintain its foundations. Large oak piles were used throughout. In the parallel rows these piles are 6 feet from center to center, bearing three heavy waling pieces and bound each to each with iron tie-rods and wooden pieces supported upon intermediate piles. In the apices the piles are but 3 feet from center to center, and an additional

waling strip is used. Cross pieces strongly bind the converging sides of the apices together.

An inspector employed upon this work by the United States was paid $85 per month.

Material dredged.—No rock and no bowlder were encountered. In the river division was found a stiff clay. In the turn-out subdivision was found clay and sand. The crib sub-division yielded principally sand, as did also the lake subdivision. At the outer end of the lake subdivision the sand was singularly hard and difficult to dig.

Table showing areas and quantities dredged, etc.

Contractor.	Locality.	Length of channel dredged.	Area dredged.	Approximate face.	Depth immediately after dredging.	Removed (scow measurement.)
			Square feet.	*Feet.*		*Cubic yards.*
James Rooney	Crib subdivision	4,000	800,000	6	16.9	165,138
L. P. & J. A. Smith	River division	3,300	373,000	2 to 10	16.8	111,967
Do	Lake subdivision	8,000	152,800	1 to 5	16.8	232,327
Do	Turn-out subdivision	3,400	419,500	5 to 6	16.8	106,740
Do	Old channel	5,000	300,000	2	17.	20,356
Total		23,700	3,420,500			636,528

The result of the dredging.—The straight channel has now been cut through to the lake. In several places, as above mentioned, the channel has not its full width, nor does the full depth of 17 feet obtain throughout, because 17 feet was the maximum depth to which, according to their specifications, contractors have been allowed to dredge, and because the work has been several years in progress and the usual fill has been going on over the dredged portions. At the present time the channel is practicable for vessels drawing 15.6 feet with the water at the mean level of 1860–1875. This is at least as good water as obtains in the old channel. The Light-House Establishment has not yet buoyed the straight channel, but when they do so and the proper lights are established, the channel may be regularly opened to navigation.

Recent condition of channel.—During May and June, 1892, an examination has been made to determine with all possible accuracy the fill that has taken place over the different parts of the channel bottom since the soundings were taken that immediately followed the dredging. Over the inner and middle sections this would show the fill for two years, and over the turn-out subdivision, crib subdivision, and lake subdivision the fill would be shown for one year. About 10,000 soundings were taken and plotted on five charts, each chart representing one of the above sections or subdivisions. The same charts show also the depths immediately after dredging, and therefore contain the data for obtaining the fill. An inspection of these charts shows that—

(1) The fill is not far from uniform over the whole length of the channel.

(2) The banks have held very well. The greater part of the fill is not from caving banks.

(3) The fill is very soft and of a sedimentary character. A large part of Maumee Bay is covered to a depth of a foot or more with this soft mud or slush, which overlies the hard sand or clay, and which appears to have been brought by the Maumee River. This slush is easily washed about, and the fill in the channel appears to be principally derived from this source, and directly by deposit from the river water.

(4) The fill over the whole channel averages a little over eight-tenths of a foot in depth. I transmit herewith a tracing, which is intended to show the extent of the fill and the present condition of the channel in characteristic sections. Each cross section drawn is the mean of from 9 to 12 actual cross sections.

Cross section A is typical of the manner of fill and present condition of the channel in the outer slope of the bar.

Cross section B is typical of the same through the bar.

Cross sections C, D, and E, represent the conditions respectively on the inner slope of the bar, in the middle section, and in the inner section near the river mouth. The middle and inner sections are the only parts of the channel that have yet been used extensively by vessels. In cross sections D and E the path of vessels is seen near the center. The fill is so soft that it is readily pushed aside by the screws of steamers.

Straight channel work in the future.—From the amount of fill mentioned above it will be seen that as at present constituted the straight channel can not maintain itself. Either extensive bank protection must be built or dredging to the extent of 200,000 cubic yards or more must be done annually. Considering the magnitude of

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the work and the continuing charges for repairs, and interest, it seems probable that the method by dredging would be most economical to the United States. To accomplish this annual dredging I would recommend the purchase of a plant by the Government. The work demands the continuous employment of one good dredge, the expense of running which would be about $30,000 per season. More would be accomplished than contractors would do for the same money, and Government work might be done more cheaply at neighboring harbors if the contractors hereabouts, who stand well together, should see that the Government is not altogether dependent upon them.

Maumee River.—A considerable shoal exists at present about 1 mile below the Pennsylvania Railroad Bridge. A preliminary examination of the river between the city docks and Maumee Bay shows that about 40,000 cubic yards should be removed to obtain a 17-foot channel throughout. The current prevents any rapid accumulation of silt here, and this dredging will probably maintain the channel for several years.

Remarks.—For purposes of inspection, survey, etc., the steamer *Swansea* was employed by the Government for a period of 222 days during the fiscal year. The average daily expense of this steamer to the Government was about $19. The crew of the *Swansea* assisted in laying out the work, taking soundings, and making surveys. During the year, in addition to her regular work, the *Swansea* removed eighteen snags from the river. An inspector was employed upon each dredge, whose duty it was to record and supervise its work. These inspectors received from $80 to $100 per month, according to their efficiency and length of service. During the past spring, while the extended examination of the harbor has been in progress, in addition to the above employés there has been a principal inspector on the work, at a salary of $120 per month.

Very respectfully, your obedient servant,

W. V. JUDSON,
Second Lieut., Corps of Engineers.

Lieut. Col. J. A. SMITH,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Toledo Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Articles.	Tons.	Articles.	Tons.
Imports.		*Exports.*	
Ore	200,893	Flour and grain	578,079
Coal	89,310	Coal	518,182
Plaster and cement	17,268	Timber	15,350
Salt	11,943		
Lumber	643		
	314,657		1,111,617

Shipping.	No.	Tonnage.
Vessels entering	2,189	968,810
Vessels departing	2,185	985,310
Vessels built	4	922.56

Total tonnage for 1891	1,954,120
Total tonnage given in last Annual Report	1,542,617
Increase	411,503

The draft of the largest vessel using the harbor is 21 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

No new lines of transportation have been established during the year.

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M M 3.

IMPROVEMENT OF PORT CLINTON HARBOR, OHIO.

Port Clinton, Ohio, is situated at the mouth of the Portage River, a stream which rises in the northwestern part of Ohio and empties into Lake Erie.

A history of the earlier operations heretofore carried on for its improvement will be found in Annual Reports of 1880 and 1881.

The present project, adopted in 1875, consists of a pile revetment 967 feet long, running from the north shore of Portage River opposite the town out into the lake, in a direction north 57 degrees east. This revetment then inclines toward the north and extends 301 feet farther, when a pile dike commences, which will be prolonged a total distance of 1,200 feet out to a depth of 10 feet at the ordinary level of the lake.

Parallel to this and 200 feet from it is an east pile pier, which will be about 2,600 feet long, its inner end resting on the south shore of the river. This east pier will be a simple pile structure of 2,450 feet; the outer 150 feet will be a strong pile dike 12 feet wide. A channel 10 feet deep will be dredged between the piers.

At the date of the last Annual Report, an agreement had been made with Messrs. Carkin, Stickney & Cram, of East Saginaw, Mich., to dredge through the bar and between the piers to obtain a channel depth of 10 feet.

Work under the agreement was commenced July 28 and completed in August. The amount of material dredged and removed from the channel was 11,705 cubic yards, measured in scows. The price paid was 25 cents per cubic yard.

The deepening of the channel causes no permanent improvement. Nearly the same conditions return annually, and with the present conditions annual expenditure for dredging will be required if the channel is to be maintained.

The project of 1875 was estimated to cost $90,000. The sum of $56,000 has been appropriated and expended since the adoption of the project, but a part has been for repairs and for dredging, which did not advance the constructions proposed.

The amount estimated in last Annual Report for completion of project was $37,000.

As the officer now in charge of the work has had no opportunity for a revision of the estimate, it is here repeated.

The following is a statement of the amount and date of all appropriations for this improvement:

June 10, 1872	$8,000	March 3, 1881	$5,000
June 10, 1872 (allotment)	2,000	August 2, 1882	6,000
March 3, 1875	5,000	August 5, 1886	2,000
August 14, 1876	5,000	August 11, 1888	5,000
June 18, 1878	10,000	September 19, 1890	3,000
March 3, 1879	10,000		
June 14, 1880	5,000	Total	66,000

Port Clinton is a port of entry in the collection district of Sandusky, Ohio. The nearest work of defense is Fort Wayne, Mich., 30 miles distant, and the nearest lighthouse is at Green Island, 10 miles distant.

The commercial statistics for the year 1891 indicate a slight decline in numbers from the previous year. The tonnage of vessels entering has not been ascertained.

Money statement.

July 1, 1891, balance unexpended	$3,000.00
June 30, 1892, amount expended during fiscal year	3,000.00
Amount appropriated by act approved July 13, 1892	10,000.00

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Amount (estimated) required for completion of existing project	$27,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	27,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Port Clinton Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Shipping.	No.	Tonnage.
Vessels entering	34	(*)
Vessels departing	32	Do.
Vessels built	1	13

* Not known.

	Tons.
Receipts—Fish and miscellaneous merchandise	3,753
Shipments—Lumber, flour, and miscellaneous merchandise	4,022

The aggregate tonnage of vessels given in last annual report was 5,149.
The largest vessels entering the harbor draw from 9 to 12 feet.

M M-4.

IMPROVEMENT OF SANDUSKY CITY HARBOR, OHIO.

Sandusky Bay empties into Lake Erie about 40 miles from its western extremity. It is a natural harbor, containing an area of about 22½ miles, a depth of from 8 to 12 feet, protected on the north and northwest from the gales of the lake by a long narrow peninsula, and on the northeast by what is known as Cedar Point.

The project adopted in 1880 provides for a channel 200 feet wide and 15 feet deep through the outer bar and in the bay, up to within 50 feet of the line of docks, and then parallel to the docks, with a width of 100 feet and depth of 15 feet.

The revised project, adopted in 1888, proposes to improve the present channel by a straight channel cut from the north end of Cedar Point to the east end of the existing channel in front of city.

For a history of this project for making a straight channel and detailed estimate of cost, see Annual Report of the Chief of Engineers for 1887, pages 2303 and 2304, and pages 2335 to 2341.

A full description of the operations carried on in earlier years for the improvement of this harbor will be found in Annual Reports of 1880 and 1881.

At the close of the last fiscal year work was in progress under a contract with Messrs. L. P. & J. A. Smith, of Cleveland, Ohio, for dredging the straight channel. Work under the contract was completed October 17, 1891,

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The amount of material removed after June 30 was 148,638 cubic yards, and the total amount under the contract was 212,962 cubic yards, measured in scows.

Other works of improvement in this harbor have been carried on simultaneously with Straight Channel, having office and other contingent expenses without a definite allotment or set of accounts for each work, so that the officer recently assigned to charge of the work finds it difficult to determine the exact amount which should be charged to cost of the Straight Channel alone. As nearly as can be determined, the amount expended on Straight Channel in last fiscal year is $27,786.22; the amount reported as expended on same to June 30, 1892, $41,199.07; total, $69,185.29.

The cost of Straight Channel originally estimated was for dredging 628.000 cubic yards, scow measurement, at 14 cents per cubic yard, $87,920; contingent expenses, $8,792; total, $96,712.

The prices by contract have been 17 and 22 cents per cubic yard, instead of 14 cents, as estimated.

At the close of last fiscal year, Messrs. Carkin, Stickney & Cram, of East Saginaw, Mich., were dredging in the old channel. Work under this agreement was completed July 23. The amount dredged in July, 1891, was 5,872 cubic yards, making a total of 9,500 cubic yards under the agreement. The cost was 25 cents per cubic yard.

The dredging was reported as giving a channel depth of 16½ feet throughout the dock channel and 15 feet in old channel.

The bar outside of Cedar Point is the worst obstruction encountered in entering the harbor.

The water over the bar is only 12 to 14 feet deep and the channel is quite narrow, the least being but about 50 feet.

The following is a statement of the amount and date of all appropriations for this improvement.

May 20, 1826 (survey)	$400	June 18, 1878	$20,000
June 11, 1844	15,000	March 3, 1879	1,000
August 30, 1852	15,000	June 14, 1880	12,500
June 28, 1864 (allotment)	10,000	March 3, 1881	10,000
June 23, 1866	38,580	August 2, 1882	10,000
July 11, 1870	10,000	July 5, 1884	20,000
June 10, 1872	13,000	August 5, 1886	5,000
March 3, 1873	25,000	August 11, 1888	40,000
June 23, 1874	25,000	September 19, 1890	45,000
March 3, 1875	25,000		
August 14, 1876	25,000	Total	365,480

Total expenditures to June 30, 1892, $365,391.46.

Sandusky City Harbor is in the collection district of Sandusky, Ohio. There is a light-house on Cedar Point with a fixed white light of the fifth order, and three range lights within the bay. Fort Wayne, below Detroit, is the nearest work of defense.

Money statement.

July 1, 1891, balance unexpended	$40,362.20
June 30, 1892, amount expended during fiscal year	38,273.66
July 1, 1892, balance unexpended	2,088.54
Amount appropriated by act approved July 13, 1892	41,712.00
Amount available for fiscal year ending June 30, 1893	43,800.54

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COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of the harbor at Sandusky City, Ohio, were compiled from information furnished by the collector of customs and others.

	Tons.
Receipts—	
Lumber	150,000
Ore	120,300
Total	270,300
Shipments, coal	164,789

Shipping.	No.	Tonnage.
Vessels entering	3,664	758,691
Vessels departing	3,699	764,819
Total		1,523,510

The aggregate tonnage given in last annual report was 1,051,108; increase, 472,402.
Draft of the largest vessel entering harbor, 15½ feet.
Depth of water prevents largest vessels from loading to full depth.
No new lines of transportation have been established during the year.

M M 5.

IMPROVEMENT OF SANDUSKY RIVER, OHIO.

The Sandusky River rises in Richland County, Ohio, and after a very circuitous course empties into Sandusky Bay about 14½ miles from Cedar Point, where the bay empties into Lake Erie.

Fremont, the head of navigation, is 17 miles from the mouth of the river. It is a city of about 9,000 inhabitants, and the market place of a large and productive surrounding country.

The history of the work carried on in earlier years for the improvement of this river will be found in annual report for 1881.

The present project, adopted in 1880, provides for dredging a channel 100 feet wide and 9 feet deep through the various bars between the city of Fremont and the depth of 9 feet in Sandusky Bay.

At the beginning of the fiscal year a contract had been made with Messrs. Carkin, Stickney & Cram, of East Saginaw, Mich., for dredging to the extent of available funds under the appropriation of September 19, 1890.

Work under the contract was commenced September 1 and completed September 15, 1891.

The amount of material dredged and removed was 5,808 cubic yards, measured in scows. The price paid was 25 cents per cubic yard.

The channel was reported to be in fairly good condition, with a least depth of 7 feet in September, 1891.

The estimated cost of the project for 9 feet depth was $44,000, but the estimate was doubtless intended to cover the first cost only of obtaining a channel if the work were done in one or two seasons. In a river like this there is a large amount of silt and other drift, which will fill the dredged cuts unless the conditions of the channel be changed by contraction works.

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In the ten years since the commencement of work on the project for 9 feet depth the drift has probably obliterated nearly all the dredging which has been done, and the expense would therefore not be materially reduced by the work already done.

It is the opinion of the officer now in charge of this improvement that dredging will afford no really permanent improvement. It would follow that unless the commerce be such that the benefits of a deeper channel are sufficient to justify a constant expense for dredging, or a very considerable outlay for contraction works, the improvement of the river will not pay as a business proposition.

The estimate here submitted for amount required to complete the present project is nearly the original estimate reduced by amount already appropriated, there being no present means of making the amount more definite, and no apparent necessity for so doing.

The following is a statement of the amount and date of all appropriations for this improvement:

March 2, 1867	$20,000	August 2, 1882	$4,000
June 10, 1872	10,000	September 19, 1890	1,500
June 14, 1880	10,000		
March 3, 1881	7,500	Total	53,000

Fremont, the head of navigation, is in the collection district of Sandusky, Ohio. The nearest light-house is at Cedar Point, the entrance to Sandusky Bay.

Fort Wayne, near Detroit, Mich., is the nearest work of defense.

No definite statistics have been received for Sandusky River. Vessels for the river are included in statistics for Sandusky Harbor.

Money statement.

July 1, 1891, balance unexpended	$1,500.00
June 30, 1892, amount expended during fiscal year	1,500.00
Amount appropriated by act approved July 13, 1892	5,000.00
Amount (estimated) required for completion of existing project	16,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	16,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

M M 6.

IMPROVEMENT OF HURON HARBOR, OHIO.

The Huron River rises in the northern part of Ohio, and after a very circuitous course empties into Lake Erie about 10 miles east of Sandusky city.

The project for the improvement of this harbor, adopted in 1826, when the mouth of the river was closed by a sand bar, and which project has been amended from time to time, as the demands of the commerce called for an increased depth of channel, consists of parallel piers, 140 feet apart, extending to the depth of 16 feet in the lake.

For a history of the earlier operations carried on in past years for the improvement of this harbor, see Annual Reports of 1880 and 1881.

The project approved in 1890 consists in extending piers to the contour of 16 feet depth in the lake and dredging channel to same depth.

This project was in compliance with the requirements of the act of

September 19, 1890, appropriating $16,000 for "improving harbor at Huron, Ohio; continuing improvement in amended project to give 16 feet depth at low water."

At the end of the last fiscal year work was in progress under a contract with Mr. John Stang, of Lorain, Ohio, for extending west pier a distance of 120 feet. This work was completed September 23, 1892. In addition to the construction, minor repairs have been made to superstructure of old piers.

The project of 1890 is about one-half completed. The old piers are, however, in a very bad condition from decay and injury by storms, and much of their superstructure should be renewed.

At the end of June, 1891, the channel between piers was reported at an average depth exceeding 16 feet, but on the bar about 150 feet outside the ends of piers the depth ranged from 14.5 to 15 feet.

The following is a statement of the amount and date of all appropriations for this improvement:

May 20, 1826	$5,000.00	June 23, 1874	$1,500.00
May 19, 1828	4,413.35	March 3, 1875	1,000.00
March 3, 1829	5,935.00	June 18, 1878	1,000.00
April 23, 1830	1,880.36	June 14, 1880	3,000.00
March 2, 1831	3,480.00	March 3, 1881	3,000.00
July 3, 1832	1,500.00	August 2, 1882	2,500.00
June 28, 1834	6,700.00	July 5, 1884	7,500.00
June 2, 1836	4,300.00	August 5, 1886	3,000.00
March 3, 1837	2,565.00	August 11, 1888	6,000.00
July 7, 1838	5,000.00	September 19, 1890	16,000.00
June 11, 1844	5,000.00		
August 30, 1852	10,000.00	Total	139,273.71
June 23, 1866	39,000.00		

The entire amount expended upon Huron Harbor to June 30, 1891, was	$128,469.43
Expenditures in last fiscal year	10,804.28
Estimated amount to complete project of 1890	13,600.00
Estimated cost of repairing old piers	12,000.00

It should be remarked that in harbors like this the woodwork of piers is constantly decaying and receiving more or less injury from other causes.

The bar at end of piers forms to a greater or less extent during each winter and spring, and as a result a part of each appropriation is necessarily expended for maintenance of piers and channel and the remainder is used is carrying out the project of improvement.

The number of vessels which entered and cleared during the last year was considerably less than in the preceding year, but the aggregate tonnage in freights was considerably more than the registered tonnage of the previous year. This indicates that a larger class of vessels is being used at this port.

Huron Harbor is in the collection district of Sandusky, Ohio. Fort Wayne, Mich., about 70 miles distant, is the nearest work of defense. There is a fixed white light of the fourth order on the outer end of the west pier.

No new lines of transportation have been established during the year.

Money statement.

July 1, 1891, balance unexpended	$10,804.28
June 30, 1892, amount expended during fiscal year	10,804.28
Amount appropriated by act approved July 13, 1892	15,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	10,600.00

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COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Huron Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Vessels entering		137
Vessels departing		157
Freight receipts	tons..	17,000
Freight shipments	do...	134,000
Total	do...	151,000

The aggregate tonnage of vessels was stated in last Annual Report as 73,464.

M M 7.

IMPROVEMENT OF VERMILLION HARBOR, OHIO.

The Vermillion River rises in the northern part of Ohio and empties into Lake Erie about 20 miles to the eastward of Sandusky City.

The project of improvement, which was adopted in 1836, when there was a depth of less than 2 feet of water over bar at entrance, and which project has been amended from time to time as the requirements of commerce demanded deeper water, consists of parallel piers, 125 feet apart, running out to a depth of 12 feet in the lake.

A history of the earlier operations carried on in the past years for the improvement of this harbor will be found in Annual Reports of 1880 and 1881.

The act of September 19, 1890, appropriated $2,000 for preservation of piers. The amount of repairs being small, the most economical and advantageous method of doing the work was by hired labor. Other and more extensive works being in progress, it was not convenient to make the repairs in last fiscal year, as was contemplated.

The repairs will be completed as far as available funds may permit during the season of 1892.

The commerce of this harbor is not sufficiently extensive or general at present to justify any large expenditure further than may be required for preservation of piers heretofore constructed, save possibly a small amount of dredging to remove small obstructions.

It is therefore proposed to apply such funds as may be appropriated to the purpose indicated.

The following is a statement of the amount and date of all appropriations for this improvement:

July 2, 1836	$10,000.00	June 18, 1878	$4,000.00
March 3, 1837	20,000.00	June 14, 1880	2,000.00
July 7, 1838	23,626.57	March 3, 1881	2,000.00
June 28, 1864 (allotment)	5,758.97	August 2, 1882	3,000.00
June 23, 1866	15,315.74	August 5, 1886	3,000.00
June 10, 1872	5,000.00	August 11, 1888	1,000.00
March 3, 1873	12,000.00	September 19, 1890	2,000.00
June 23, 1874	3,000.00		
March 3, 1875	10,000.00	Total	126,701.28
August 14, 1876	5,000.00		

Vermillion Harbor is in the collection district of Sandusky, Ohio. There is a fixed light of the fifth order on the west pier. Fort Wayne, Mich., 80 miles distant, is the nearest work of defense.

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Money statement.

July 1, 1891, balance unexpended	$2,000.00
July 1, 1892, balance unexpended	2,000.00
Amount appropriated by act approved July 13, 1892	2,000.00
Amount available for fiscal year ending June 30, 1893	4,000.00
Amount (estimated) required for completion of existing project	6,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	6,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Vermillion Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Vessels entering	34
Vessels departing	33
	Tons.
Receipts: Lumber, pound poles, and fishing tackle	2,000
Shipments: Timber, fish, and fishing tackle	1,000

The draft of the largest vessel entering the harbor is 15½ feet, As the depth of water in the harbor is only 10 to 12 feet, the largest vessels can not load to full depth.

The chief industry of the port is fishing.

No record is kept of the amount brought in.

M M 8.

IMPROVEMENT OF BLACK RIVER HARBOR, OHIO.

Black River, Ohio, is formed by two branches nearly equal in size, which, rising in Lorain County, Ohio, and following northward, unite about 8 miles from the town of Lorain, where the river empties into Lake Erie.

A history of the operations carried on during the past years, whereby the depth at the entrance to this harbor has been increased from about 3 feet to at least 16 feet, will be found in Annual Reports of 1880 and 1881.

The project of improvement submitted in 1828, and amended from time to time as the demands of commerce called for an increased depth in channel, provides for parallel piers 200 feet apart, running out from the shore on each side of the mouth of the river to a depth of 16 feet in the lake.

At the beginning of the fiscal year work was in progress under a contract with Mr. John Stang, of Lorain, Ohio, for extending the east pier a distance of 102 feet.

The date of expiration of the contract was originally August 1, 1891. Owing to failure to receive materials for the construction, the contractor was granted an extension to August 30, and subsequently a second, extending the time for completion of contract to September 30, 1891. Work under the contract was completed September 12, 1891.

In addition to work of pier extension some minor repairs were made to the superstructure of old piers. The superstructure of old piers is in bad condition from decay and injury by storms and ice.

In the last annual report the officer then in charge of the improvement recommended that provision be made for 17 feet depth of water at an estimated cost of $40,000 in addition to the project previously adopted. The estimate is here repeated with the remark that the officer now in charge of the work has had no means of judging of the necessity for the work or the accuracy of the estimate.

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At the close of the last fiscal year the channel was reported to be 16 feet deep. No examinations of the channel have been made since that date.

The following is a statement of the amount and date of all appropriations for this improvement:

May 23, 1828	$7,500.00	March 3, 1873	$20,000.00
April 23, 1830	8,559.77	June 23, 1874	20,000.00
March 2, 1831	9,275.00	March 3, 1875	10,000.00
July 3, 1832	8,000.00	August 14, 1876	6,000.00
March 2, 1833	2,400.00	June 18, 1878	1,000.00
June 28, 1834	5,000.00	June 14, 1880	1,000.00
March 3, 1835	4,400.00	March 3, 1881	7,000.00
July 2, 1836	6,660.00	August 2, 1882	7,000.00
March 3, 1837	6,410.00	July 5, 1884	10,000.00
July 7, 1838	5,000.00	August 5, 1886	10,000.00
August 30, 1852	5,000.00	August 11, 1888	10,000.00
June 28, 1864 (allotment)	20,000.00	September 19, 1890	12,000.00
June 23, 1866	10,000.00		
June 10, 1872	20,000.00	Total	232,204.77

Black River is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the fourth order at the outer end of the west pier. The nearest work of defense is Fort Wayne, Mich., 80 miles distant.

The number of vessels reported as entering and leaving the harbor in the year 1891 is less than statistics for previous year. The later figures were furnished by the collector of customs and are presumed to be approximately correct.

On the other hand the tonnage in freights reported is greater than in the preceding year.

Money statement.

July 1, 1891, balance unexpended	$9,276.77
June 30, 1892, amount expended during fiscal year	9,276.77
Amount appropriated by act approved July 13, 1892	20,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	38,000.00

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Black River Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Articles.	Tons.	Articles.	Tons.
Imports.		*Exports.*	
Ore	270,240	Coal	450,513
Lumber	9,143	Lumber	16
Railroad ties	3,774	Miscellaneous	15
Telegraph poles	5,000		
Stone	46	Total	450,544
Total	288,203		

Shipping.	No.	Tonnage.
Vessels entering	288	Not known.
Vessels departing	305	Do.
Vessels built	1	9.33

Total tonnage for 1891 (estimated), 800,000.

The draft of the largest vessel entering the harbor was 21 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

No new lines of transportation established.

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M M 9.

IMPROVEMENT OF CLEVELAND HARBOR, OHIO.

Cleveland, Ohio, is situated at the mouth of the Cuyahoga River. This river rises in the northern part of Ohio and after a very circuitous course empties into Lake Erie.

The original project of improvement, adopted in 1825, when there was a depth of only 3 feet in the narrow and crooked channel at the entrance, and which project has been amended from time to time as the demands of commerce called for an increased depth of water, provides for parallel piers 200 feet apart, running out to a depth of 16 feet in the lake. This project is completed.

In 1875, in accordance with an act of Congress, a plan was submitted for a harbor of refuge at this place.

The amended plan for this outer harbor consists of two breakwaters.

The shore arm of the west breakwater starts from a point about 700 feet west of the extremity of the old bed of the Cuyahoga River and runs out into the lake in a direction nearly due north a distance of 3,130 feet.

The lake arm, which is about parallel with the main shore, is 4,030 feet long, and at a point 200 feet from its eastern extremity a spur 100 feet long runs out at right angles so as to break the force of the heavy sea rolling along the breakwater during westerly and northwesterly gales. All this portion was completed in December, 1883.

The proposed east breakwater, under the latest plan, begins at a point on the prolongation of the lake arm of the west breakwater and 500 feet from it, extends eastward on this line about 3,500 feet, then inclines toward the shore, and extends 2,000 feet in a depth of 26 feet of water, and having between its eastern end and the curve of 14 feet depth of water an entrance 2,300 feet wide.

For a history of this change in plan for harbor of refuge, see Annual Reports of 1884, 1885, 1886, and 1888.

At the beginning of the fiscal year work was in progress, extending the east breakwater, under a contract with Messrs. L. P. & J. A. Smith, of Cleveland, Ohio.

The contract was completed November 23, 1891. By this work the east breakwater was extended eastward a distance of 452⅓ linear feet, making the total length completed of breakwater 9,308⅓ feet. The amount remaining to complete the breakwater, as planned, is 3,350 linear feet.

Work under contract with Messrs. Carkin, Stickney & Cram was continued from July 1 to July 15, when it was completed to extent of available funds.

The amount of material removed in July was 4,786 cubic yards, making a total under the contract of 18,286 cubic yards, measured in scows. In the spring of 1892, the breakwaters were found to be considerably injured by ice and winter storms.

Repairs, which could be undertaken, were necessarily limited by funds available for the purpose, which amounted to but $1,500. These repairs were commenced in June, but were delayed owing to the difficulty of procuring certain pieces of oak lumber which were necessary for the purpose.

The repairs will be completed early in July.

In April, 1892, soundings were taken to ascertain the condition of the channel from the railroad bridge to the opening in breakwater. The soundings show that the channel depths in the river have been

fully maintained to a point about 400 feet inside the ends of piers, where a shoaling is perceived. From the end of the piers outward a distance of 400 feet the channel has an average of about 2 feet less depth than in July, 1891, referred to the mean lake level.

The actual present depth is, however, nearly the same as last year, as the mean surface level of the lake in June, 1892, was 1.73 feet higher than in June, 1891. The least depth in the channel on the bar in April, 1892, was 15.2 feet, referred to mean lake level.

At a point 50 feet below the bridge the channel is 165 feet wide; the greatest depth exceeds 20 feet and the average is about 18 feet.

The piers are not parallel, but diverge so that they are 250 feet apart at the outer ends. The result of the divergence is plainly shown in the shoaling of the river.

It is apparent that no very deep channel can be relied upon without a considerable annual expenditure for dredging.

The mud and drift brought down by the river during freshets is also forming a bar across the entrance to the anchorage basin behind the west breakwater. It is also reported that the anchorage basin itself is gradually becoming filled from various causes, such as sewerage, illegal dumping, drift, etc. How far the statements are correct can only be determined by careful examination, and it is therefore proposed to make a good hydrographic survey of the harbor in the summer of 1892. The area of the outer harbor, which was planned as a harbor of refuge, is now more than ample for all the present demands upon it, and there seems to be more need of greater depth in the west basin than of increasing the area for anchorage on the east side.

All the business of the harbor is done in the river. About one mile of the lake front on the west side of the river is fully protected from seas by the breakwaters, and harbor lines were established some years ago, but no part of it has thus far been utilized for business purposes.

The following is a statement of the amount and date of all appropriations for this improvement:

March 3, 1825 (survey)	$5,000.00
March 2, 1827	10,000.00
March 3, 1829	12,179.00
April 23, 1830	1,786.56
March 2, 1831	3,670.00
July 3, 1832	6,600.00
June 28, 1834	13,315.00
July 2, 1836	15,006.59
March 3, 1837	10,000.00
July 7, 1838	51,856.00
June 11, 1844	25,000.00
August 30, 1852	30,000.00
March 3, 1853	145.69
June 28, 1864 (allotment)	20,000.00
June 23, 1866	59,806.00
July 25, 1868 (allotment)	17,000.00
April 10, 1869 (allotment)	13,380.00
July 11, 1870	20,000.00
March 3, 1871 (allotment for repairs	*636.77
March 3, 1873	1,000.00
June 23, 1874	30,500.00
Total previous to adoption of project for harbor of refuge	346,881.61
March 3, 1875	$50,000
August 14, 1876	50,000
August 14, 1876 (repair of pier)	8,000
June 18, 1878	100,000
March 3, 1879	100,000
June 14, 1880	125,000
March 3, 1881	200,000
August 2, 1882	175,000
July 5, 1884	100,000
August 5, 1886	93,750
August 11, 1888	100,000
September 19, 1890	75,000
Total appropriated since adoption of present project	†1,176,750
Amount expended to June 30, 1892	$1,167,118.25

* Difference between $1,000 and the amount which reverted to the Treasury.

† About $50,000 of this amount has been expended in maintenance of the old piers nd channel.

Cleveland harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the third order on the shore and a beacon on the outer end of each pier, and a beacon with flash light and fog-whistle on the independent crib, just inside the east end of the lake arm of the breakwater. The nearest work of defense is Fort Wayne, Mich., 110 miles distant.

Money statement.

July 1, 1891, balance unexpended	$56,350.15
June 30, 1892, amount expended during fiscal year	54,718.40
July 1, 1892, balance unexpended	1,631.75
July 1, 1892, outstanding liabilities	233.87
July 1, 1892, balance available	1,397.88
Amount appropriated by act approved July 13, 1892	100,000.00
Amount available for fiscal year ending June 30, 1893	101,397.88
Amount (estimated) required for completion of existing project	344,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	344,250.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Cleveland Harbor, Ohio, were compiled from information furnished by the collector of customs and others:

Articles.	Tons.	Articles.	Tons.
Imports.		*Exports.*	
Ore	1,375,144	Coal and coke	1,393,895
Lumber	1,107,038	Iron and steel	99,428
Flour and grain	123,983	Oil and grease	29,658
Stone	118,701	Stone	18,731
Fish	84,721	Lumber	16,540
Iron	49,331	Flour and grain	2,763
Ice	18,250	Brick	3,424
Salt	3,595	Plaster, cement, and lime	954
Plaster and cement	2,844	Miscellaneous	46,478
Coal	2,967		
Miscellaneous	9,770	Total	1,616,871
Total	2,895,894		

Shipping.	No.	Tonnage.
Vessels entering	3,039	(*)
Vessels departing	3,151	(*)
Vessels built	17	12,792.08

* Not known.

Total tonnage for 1891 (estimated), 5,000,000, varying little from amount given in last annual report.

The draft of the largest vessel entering the harbor was 21 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

The following lines of transportation were established during the year:

Lakewood Transportation Company of Rockport, Ohio.

Cleveland and Lakeside Steam Navigation Company of Cleveland, Ohio.

Hawgood & Avery Transit Company of Mantua, Ohio.

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M M 10.

IMPROVEMENT OF FAIRPORT HARBOR, OHIO.

Grand River rises in the northeastern part of Ohio, and after a very circuitous course empties into Lake Erie at a point about midway between the eastern and western extremities.

A full description of the earlier operations carried on for the improvement of this harbor during past years will be found in Annual Reports of 1880 and 1881.

The project of improvement adopted in 1825, when the mouth of the river was closed by a sand bar so hard and dry in summer that teams could drive across, and which project has been amended from time to time since that date, as the demands of commerce called for an increased depth in the channel, provides for parallel piers, 200 feet apart, running out from each side of the entrance to a depth of 16 feet in the lake.

Revised project of 1890 provides for extension of piers to depth of 18 feet in the lake, and dredging to secure 18 feet depth in channel.

At the close of the last fiscal year a contract was outstanding with the American Transportation Company, of Painesville, Ohio, for dredging in the channel of the river and on the bar at its mouth.

Work was continued under the contract until July 30, when the time expired by limitation, and the contract was annulled in accordance with its terms.

The amount dredged in the month of July was 9,291 cubic yards. The total amount dredged under the contract was 51,292 cubic yards, and at the time of its annulment there remained about 13,500 cubic yards to complete it.

Proposals for dredging were invited by circular letter, and the proposals were opened September 5. The lowest bid was from J. R. Irwin, of Painesville, Ohio, and a contract was entered into with him, dated September 21, 1891, to do the dredging at 17½ cents per cubic yard.

Work under the contract was commenced October 5 and completed November 23, the total amount dredged under the contract being 42,062 cubic yards.

The reason for the large excess in amount done over that required to complete the former contract was that the forfeitures of amounts due under the first contract increased the amount of available funds which could be expended under the second.

By this dredging the channel was given a depth of 17 feet between the piers and through the bars in the lake near end of piers.

In the spring of 1892 the bars had again formed so that the channel depth did not exceed 14 feet. The necessity for immediate relief by dredging through the bars was urgently represented, and the amount of dredging required being too small to attract any competition in doing the work by contract, an agreement was made with the American Transportation Company, which owns the only dredging plant at Fairport Harbor, to furnish an outfit of dredge, scows, and tug, with their crews, and to do the work at the rate of $75 per day. The commencement of work as well as its completion was greatly delayed by the windy weather which was phenomenally bad. Dredging was commenced April 21 and completed on the 4th of June, the number of days in which the dredge could work on the bar during that time being but ten and a half.

The channel was opened through the bar to a depth of 17 feet. No examination has been made between the piers to ascertain the condi-

tion of the channel at close of fiscal year, but no complaint has been received.

The work of pier extension was continued from July 1 to August 31, when it was completed. The entire amount done under the contract consisted in extending the east pier a distance of 120 feet and the west pier 80 feet. General repairs were also made to old piers.

The commerce of this harbor is rapidly increasing, and it is probable that additional facilities of increased depth in channel will be required in the near future.

Appropriations have been made for Grand River and Fairport Harbor, from 1825 to 1890, inclusive, as follows:

March 3, 1825	$1,000.00	June 18, 1878	$5,000.00
May 20, 1826	5,620.00	June 14, 1880	3,000.00
May 19, 1828	9,135.11	March 3, 1881	10,000.00
April 23, 1830	5,563.18	August 2, 1882	10,000.00
March 2, 1831	5,680.00	July 5, 1884	10,000.00
July 3, 1832	2,600.00	August 5, 1886	18,750.00
June 28, 1834	10,000.00	August 11, 1888	10,000.00
July 2, 1836	6,000.00	September 19, 1890	30,000.00
July 7, 1838	10,000.00		
June 11, 1844	10,000.00	Total	320,873.53
August 30, 1852	10,000.00		
June 28, 1864	24,453.24	Amount expended to June 30, 1891	299,469.82
June 23, 1866	24,072.00		
March 2, 1867	60,000.00	Amount expended in last fiscal year	20,033.26
June 23, 1874	20,000.00		
March 3, 1875	15,000.00		
August 14, 1876	5,000.00	Total to June 30, 1892	319,503.08

Fairport Harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the third order on the shore and a beacon on the east pier.

Money statement.

July 1, 1891, balance unexpended	$21,403.71
June 30, 1892, amount expended during fiscal year	20,033.26
July 1, 1892, balance unexpended	1,370.45
Amount appropriated by act approved July 13, 1892	35,000.00
Amount available for fiscal year ending June 30, 1893	36.370.45
Amount (estimated) required for completion of existing project	79,400.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	79,400.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Abstract of proposals for dredging at Fairport Harbor, Ohio, received and opened by Maj. L. Cooper Overman, Corps of Engineers, at Cleveland, Ohio, at 5 o'clock p. m., September 5, 1891, in accordance with circular letter dated August 22, 1891.

[Net amount available, $7,500.]

Name and address of bidders.	Price per cubic yard, measured in scows (30,000 cubic yards, more or less).	Total.
	Cents.	
J. R. Irwin, Painesville, Ohio	17½	*$5,250
James Rooney, Toledo, Ohio	25	7,500
John Stang, Lorain, Ohio	23	6,900

* Lowest bid received.

Recommended that contract be awarded to J. R. Irwin, Painesville, Ohio, at the rate of 17½ cents per cubic yard, scow measurement.

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ABSTRACT OF CONTRACT FOR IMPROVING HARBOR AT FAIRPORT, OHIO, IN FORCE DURING THE FISCAL YEAR ENDING JUNE 30, 1892.

(1) Contract with J. R. Irwin, of Painesville, Ohio, dated September 21, 1891, for dredging 42,000 cubic yards, more or less, of material from channel of Fairport Harbor; also Grand River, Ohio.

Rate paid, 17½ cents per cubic yard, scow measurement.

Contract expires December 10, 1891.

Contract completed and closed.

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Fairport Harbor, Ohio, were compiled from information furnished by the collector of customs and others.

Articles.	Tons.	Articles.	Tons.
Imports.		*Exports.*	
Ore	698,831	Coal	156,992
Flour and grain	53,047	Sugar	5,576
Stone	6,700	Canned goods	1,957
Lumber	4,882	Miscellaneous	1,216
Miscellaneous	1,054	Total	165,741
Total	764,514		

Vessels arriving 506
Vessels departing 439

Total tonnage for 1891 (estimated), 1,300,000, varying little from amount given in last annual report.

The draft of the largest vessel entering the harbor was 21 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

The following lines of transportation were established during the year:

The Mentor Steamship Company,

The Mitchell Steamship Company.

M M 11.

IMPROVEMENT OF ASHTABULA HARBOR, OHIO.

The original project for the improvement of this harbor was adopted in 1826, at which time there was a depth of only 2 feet of water on the bar. This project has been modified from time to time in order to meet the demands of commerce and increased draft of vessels navigating the lake. As at present being carried out, it provides for piers running out into the lake to 16 feet depth and to excavate channel through bar and between piers to secure 17 feet depth.

The last project, adopted in July, 1890, provides for the extension of piers to 22 feet natural depth in lake and excavation of channel between piers to 20 feet at mean low water.

Before operations were commenced rock was encountered at 7 to 9 feet below water surface, extending across the channel in the form of a wide reef, which required blasting and dredging for its removal in order to secure the present depth of 16 feet.

At the close of the last fiscal year, a contract was outstanding with Messrs. Carkin, Stickney and Cram, of East Saginaw, Mich., for dredg-

ing the shale rock and loose material which form the bottom of the harbor and extend into the lake.

Under authority of the Chief of Engineers, the contract was extended from July 30 to August 30, and subsequently to September 30, 1891. Work was continued under the contract until September 26, when it was completed.

The amount of rock and shale measured in scows and removed subsequent to June 30, was 22,271 cubic yards, and the total under the contract was 28,956 cubic yards.

In the spring of 1892 it was ascertained that the channel through the bar had become filled. The necessity for dredging the channel immediately was urgently represented. The amount required was too small to attract any competition if advertised, and a dredge, scows, and tug were therefore hired by the day to do the necessary work. The only dredge available at the harbor was owned by the Pennsylvania Railroad Company. It was hired with the scows at $50 per day, including crew, and the same parties furnished a tug at the rate of $30 per day.

The weather was exceedingly bad for work upon the bar. Dredging was commenced April 7, and on the 6th of June it was suspended. During that time the dredge could work on the bar but 45¾ hours.

The amount of material removed was 1,895 cubic yards. As a result a channel about 100 feet wide was dredged to a depth of 18 feet through the bar.

The annual formation of a bar at the mouth of the river must be expected at least until after the piers have been extended into deeper water of the lake. How far any such trouble may be experienced after that is done can be determined by experience only, but it is not probable that the formation will be as rapid as before, because the action from waves on the bottom will be less, and the drift from the river will have a larger area of deep water into which it may fall.

Ashtabula is one of the largest shipping points for ore on Lake Erie, and the necessity for deeper water in the channel is urgent. The Lake Shore and the Pennsylvania Railroad companies are expending large amounts in improving their facilities for receiving and shipping iron ore, and the present channel is insufficient for the demands upon it.

Ashtabula Harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the fifth order, varied by flashes, on the west pier.

Fort Porter, New York, is the nearest work of defense.

Appropriations for improving this harbor from 1826 to 1890 have been made, as follows:

May 20, 1826	$12,000.00	June 23, 1874	$35,000.00
May 19, 1828	2,403.50	March 3, 1875	25,000.00
March 3, 1829	6,940.25	August 14, 1876	5,000.00
March 2, 1831	7,015.00	June 18, 1878	12,000.00
July 3, 1832	3,800.00	March 3, 1879	9,000.00
March 2, 1833	3,400.00	June 14, 1880	20,000.00
June 28, 1834	5,000.00	March 3, 1881	20,000.00
March 3, 1835	7,591.00	August 2, 1882	20,000.00
March 3, 1837	8,000.00	July 5, 1884	22,500.00
July 7, 1838	8,000.00	August 5, 1886	30,000.00
June 11, 1844	5,000.00	August 11, 1888	25,000.00
August 30, 1852	10,000.00	September 19, 1890	40,000.00
March 3, 1853	42.64		
June 23, 1866	24,708.82	Total	467,401.21
March 2, 1867	54,000.00	Total expended to June 30, 1892, including liabilities	458,734.46
March 3, 1871	15,000.00		
June 10, 1872	15,000.00		
March 3, 1873	16,000.00		

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Money statement.

July 1, 1891, balance unexpended	$39,090.49
June 30, 1892, amount expended during fiscal year	30,203.74
July 1, 1892, balance unexpended	8,886.75
July 1, 1892, outstanding liabilities	220.00
July 1, 1892, balance available	8,666.75
Amount appropriated by act approved July 13, 1892	70,000.00
Amount available for fiscal year ending June 30, 1893	78,666.75
Amount (estimated) required for completion of existing project	244,392.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	150,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The following statistics for the year 1891, relative to the commerce of Ashtabula Harbor, Ohio, were compiled from information furnished by the collecter of customs and others:

Imports:	Tons.
Ore	1,526,198
Lumber	4,925
Pig iron	973
Ice	301
Miscellaneous	535
Total	1,532,932
Exports: Coal	506,297

Shipping.	No.	Tonnage.
Vessels arrived	1,046	Not known.
Vessels departed	1,008	Do.
Vessels built	1	7.3

Total tonnage for 1891 (estimated), 2,500,000, varying little from amount given in last annual report.

No new lines of transportation have been established during the year.

The draft of the largest vessel entering the harbor is 21 feet.

The depth of water in the harbor prevents the largest vessels from loading to full depth.

M M 12.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

In the spring of 1892 information was received that two small wrecks, which had been abandoned in the harbor of Port Clinton, Ohio, were obstructions to navigation at that place. One of the wrecks was the hull of the sailboat *Rescue* and the other of the steam tug *Wilcox*.

An examination of the situation was made by Lieut. Judson, and from his report the officer in charge of the improvement of that harbor considered that the obstructions were such as are covered by section 4 of the river and harbor act of June 14, 1880. An estimate of $100 was submitted for removal of the wrecks. This was approved and the allotment made by the Secretary of War May 17, 1892.

Although the obstructions are small it was not convenient to undertake their removal previous to June 30. The work will be done at the first convenient opportunity in the summer of 1892.

M M 13.

[Printed in House Ex. Doc. No. 61, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF GRAND RIVER, OHIO, BETWEEN RICHMOND AND THE MOUTH.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 20, 1890.

GENERAL: In compliance with circular letter from the office of the Chief of Engineers, U. S. Army, dated September 20, 1890, I have the honor to submit the following report of "preliminary examination" for survey of "Grand River, Ohio, between Richmond and the mouth," as provided for in section 17 of the river and harbor act approved September 19, 1890.

It is assumed that the object of the survey or examination required is with view to deepening the existing channel of the river so that large-sized vessels can get to Richmond docks to discharge their cargo.

Grand River rises in the northeastern part of the State of Ohio, and flowing first north, then west, and then north, after a very circuitous course empties into Lake Erie at a point about midway between its eastern and western extremities. Fairport Harbor is at the mouth of Grand River. Richmond is located on the west bank of the stream about 1¼ miles from the present mouth of the river, and before the improvement of Fairport Harbor was the port of entry for the neighboring country.

At Richmond, and from thence down to the piers, the river is about 320 feet wide and of varying depth. An irregular channel, of least width of 100 feet and least depth of 9 feet, averaging about 12 feet, now exists, but with comparatively small amount of dredging can be made 160 feet wide and 18 feet deep.

The docks of the railroad company and ore storage companies extend on the right bank of the river from point opposite Richmond to United States piers at Fairport, about 1 mile in length.

At Richmond there has been built a dock 1,000 feet long, on which there is being erected a grain elevator capable of storing 1,000,000 bushels; also two immense storage warehouses for storing general merchandise.

Fairport Harbor is now the third harbor on the list of Lake Erie harbors in order of amount of ore received and coal shipped. During the season of navigation now drawing to a close (1890), Fairport Harbor will have received over 1,000,000 tons of ore as against 829,000 tons in 1889, and against only 112,000 tons in 1885, and the amount of this commerce bids fair to increase still more as other railroad companies are preparing to build to said harbor. With present dock facilities 12,000 tons of ore can be handled daily, and there is storage capacity for 1,000,000. The use of steam shovels for loading from dock to cars gives good dispatch to the ore.

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New improvements in the way of new docks and new hoisting ma-

chinery, and other general improvements, are contemplated before next season.

Fairport Harbor, therefore, amply repays for all moneys expended for its improvement, and deserves liberal appropriations for its speedy improvement.

Owing to the increased size of vessels now in use on the lakes in transporting ore and coal, and on account of the very large increase, in recent years, in the commerce seeking Fairport Harbor, Ohio, it is necessary and proper that all projects for the improvement of the channel should contemplate not less than 18 feet from lake to inner end of railroad docks on Grand River.

On the above basis the following rough estimate of cost to improve Grand River, Ohio, from Richmond to the mouth, to give channel 18 feet deep, is submitted:

Channel 150 feet wide, 7,000 feet long, and excavated to 18 feet depth—average cut of 3 feet—gives 115,500 cubic yards place measure, or, say, 125,000 cubic yards, scow measure, at 18 cents per cubic yard, is	$22,500
Contingent expenses, say	2,500
Total	25,000

I am of the opinion that Grand River is worthy of improvement, and that the demands of commerce, present and prospective, call for the improvement of the channel at the locality mentioned.

Fairport Harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the third order on the shore and a beacon on the east pier.

There were no revenue collections during the eleven months ending May 31, 1890. During same period the imports, consisting of iron ore and lumber, amounted in value to $4,980,000; and the exports, consisting of coal, amounted in value to $192,000.

Five hundred and seventy-two vessels entered (aggregate tonnage not stated), and 460 vessels cleared, whose aggregate tonnage was 96,000 tons.

The largest cargo of vessels entering or clearing was 2,476 tons, and the deepest draft was 16½ feet.

The above statistics, obtained from the deputy collector at Fairport Harbor, were all that could be obtained, the collector of customs at Cleveland being unable to furnish items and figures desired.

In further compliance with terms of circular letter from the office of the Chief of Engineers, U. S. Army, dated September 29, 1888, I have to respectfully submit estimate of cost of survey, as follows:

FIELD WORK.

Services of an assistant engineer, say twenty-five days, at $160 per month	$133.33
Services of leadsman and rodman, say twenty-five days, at $90 per month	75.00
Services of two laborers, as axmen and boatmen, say twenty-five days, at $2 per day each	100.00
Hire of two boats, say twenty days, at $1 per day each	40.00
	348.33

OFFICE WORK.

Services of assistant engineer, making estimates, profiles, maps, plotting, etc., say thirty days, at $160 per month	$160.00
Total	508.33

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This survey should be made as soon as possible if it is to be made this winter.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. Henry L. Abbot, Corps of Engineers, Division Engineer, Northeast Division.)

[First indorsement.]

NORTHEAST DIVISION, ENGINEER OFFICE,
New York, November 22, 1890.

Respectfully forwarded to the Chief of Engineers, U. S. Army.

I concur with Major Overman's opinion that, for the reason stated, "Grand River, between Richmond and the mouth," is worthy of improvement.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
Engineer Northeast Division.

SURVEY OF GRAND RIVER, OHIO, BETWEEN RICHMOND AND THE MOUTH.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 10, 1891.

GENERAL: In compliance with letter from the office of the Chief of Engineers, U. S. Army, dated November 25, 1890, I have the honor to submit the following report of a survey of "Grand River, Ohio, between Richmond and the mouth," as provided for in section 17 of the river and harbor act approved September 19, 1890.

It was assumed that the object of the survey or examination required was with view to deepening the existing channel of the river so that large sized vessels can get to Richmond docks to discharge their cargo.

Grand River rises in the northeastern part of the State of Ohio, and, flowing first north, then west, and then north, after a very circuitous course empties into Lake Erie at a point about midway between its eastern and western extremities. Fairport Harbor is at the mouth of Grand River. Richmond is located on the west bank of the stream, about 1⅜ miles from the present mouth of the river, and, before the improvement of Fairport Harbor, was the port of entry for the neighboring country.

At Richmond and from thence down to the piers the river is about 285 feet wide and of varying depth. An irregular channel, of least width of 90 feet and least depth of 9 feet, averaging about 14 feet, now exists, but with comparatively small amount of dredging can be made 160 feet wide and 18 feet deep.

The docks of the railroad company and ore-storage companies extend on the right bank of the river from point opposite Richmond to United States piers at Fairport, about 1 mile in length.

At Richmond there has been built a dock 1,035 feet long, on which there has been erected a grain elevator capable of storing 1,000,000 bushels, also two immense storage warehouses for storing general merchandise.

Fairport Harbor is now the third harbor on the list of Lake Erie har-

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bors in order of amount of ore received and coal shipped. During the season of navigation now drawing to a close (1891) Fairport Harbor will have received over 1,000,000 tons of ore as against 1,000,000 tons in 1890, and against only 112,000 tons in 1885, and the amount of this commerce bids fair to increase still more as other railroad companies are preparing to build to said harbor.

With present dock facilities 12,000 tons of ore can be handled daily, and there is storage capacity for 1,000,000. The use of steam shovels for loading from dock to cars gives good dispatch to the ore.

New improvements, in the way of new docks and new hoisting machinery and other general improvements, are contemplated before next season.

Fairport Harbor, which includes Grand River as far as Richmond, therefore amply repays for all moneys expended for its improvement, and deserves liberal appropriations for its speedy improvement.

Owing to the increased size of vessels now in use on the lakes in transporting ore and coal, and on account of the very large increase in recent years in the commerce seeking Fairport Harbor, Ohio, it is necessary and proper that all projects for the improvement of the channel for harbors and rivers should contemplate not less than 18 feet from lake to inner end of railroad docks on Grand River.

On the above basis the following approximate estimate of cost to improve "Grand River, Ohio, from Richmond to the mouth" by dredging to give channel 18 feet deep is submitted:

Channel 160 feet wide, 7,310 feet long, and excavated to 18 feet depth, average cut of 4.016 feet, gives 160,000 cubic yards, place measure, or, say, 196,000 cubic yards, scow measure, dredging at 18 cents per cubic yard, is..	$35,280
Contingent expenses, say	3,720
Total	39,000

I am of the opinion that Grand River, from Richmond to the mouth, is worthy of improvement, and that the demands of commerce, present and prospective, call for the improvement of the channel at the locality mentioned. A chart (tracing) of locality is transmitted herewith in separate package.*

Fairport Harbor is in the collection district of Cuyahoga, Ohio, There is a fixed white light of the third order on the shore and a beacon on the east pier.

During the eleven months ending May 31, 1891, the amount of revenue collected was $1.50.

The imports, consisting of iron ore and lumber, stone and flour, amounted in value to $4,542,493, and the exports, consisting of coal, amounted in value to $125,350.

Five hundred and ninety-three vessels entered, with an aggregate tonnage of 683,068 tons; and 526 vessels cleared, whose aggregate tonnage was 619,615 tons, during the eleven months ending May 31, 1891.

The largest cargo of vessels entering or clearing was 2,805 tons, and the deepest draft was 17 feet.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. Henry L. Abbot, Corps of Engineers, Division Engineer, Northeast Division.)

* Not printed.

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[First indorsement.]

NORTHEAST DIVISION, ENGINEER OFFICE,
New York, November 14, 1891.

Respectfully forwarded to the Chief of Engineers, U. S. Army.

There can be no doubt that Grand River below Richmond is worthy of improvement. Whether this shall be done by the United States or by the local interests is a matter for Congress to determine.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
Engineer Northeast Division.

M M 14.

[Printed in House Ex. Doc. No. 42, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF CONNEAUT HARBOR, OHIO.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 3, 1890.

GENERAL: In compliance with circular letter from the office of the Chief of Engineers, dated September 20, 1890, I have the honor to submit the following report of "preliminary examination" for survey of Conneaut Harbor, Ohio, as provided in section 17 of the river and harbor act approved September 19, 1890.

Conneaut Harbor, Ohio, is situated at the mouth of Conneaut Creek, about 30 miles west of Erie, Pa., and 13 miles east of Ashtabula, Ohio.

The creek empties into Lake Erie near the boundary line between the States of Pennsylvania and Ohio, and although a narrow stream presents a depth of 15 feet after passing inside the piers. The attention of the General Government was first called to this locality for a harbor in 1829, when there was a depth of only 2 feet at the entrance to the harbor. Since that date the appropriations have amounted to $112,629.39, the last appropriation being that of June 14, 1880, for $6,000. The work for the improvement of this harbor has been continued during fifty-one years, with many interruptions and suspensions for want of funds.

The best channel depth ever obtained at the entrance was only 11 feet, the more usual depth being from 8 to 9 feet. The project for improvement was designed to give a depth of 12 feet, but the plan was never carried to completion for want of sufficient appropriations. The appropriation of 1880 of $6,000 was expended in making the most pressing repairs, and it was estimated by the then engineer in charge that at least $35,000 should be expended in renewals and repairs, and an annual expenditure of $1,000 to maintain piers. No appropriation has been made since 1880, and no work done since 1881.

The commerce of the port has always been very small. We may therefore conclude that the hopes entertained for this harbor when its improvement was undertaken have never been realized.

Reports that surveys were being made for extending a line of railroad to Conneaut Harbor for a lake terminus have been circulated a number of times, but nothing definite has yet been done.

At present the harbor is virtually destroyed; the piers are nearly destroyed, breaches having been made in both, so that the stream now finds an outlet through the east pier, causing a bar, dry at low water, near the entrance at end of piers. Very extensive repairs and renewals are necessary, together with a large expenditure for dredging.

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A rough estimate as to what the proposed improvement would cost would be as follows:

For a channel entrance 160 feet wide, 18 feet deep:	
Dredging from 18 feet depth in lake to inside, say 150,000 cubic yards of material, at about 18 cents per cubic yard	$27,000
Repairs and renewals of piers and revetment, estimated in 1880 at $35,000, which now would cost not less than	50,000
Additional renewals, repairs, and enlargement of harbor necessitated by present demands of lake commerce, say	141,000
Contingent expenses on above estimate, say 15 per cent	32,700
Total	250,700

With a line of railroad from the coal regions of Pennsylvania to Conneaut Harbor the commerce would doubtless increase rapidly and the harbor be frequented by vessels of the larger class now navigating the lakes, and render the reconstruction of the harbor necessary. With a line of railroad constructed, I am of the opinion that the desired improvement to restore the harbor and to deepen and widen entrance to same is a worthy one, but without such a road built or assured any outlay for the improvement of the harbor is injudicious.

Conneaut is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the sixth order upon the bank of lake near mouth of creek, the light beacon having been removed from end of pier on account of the dilapidated condition of the piers. Fort Porter, N. Y., 100 miles distant, is the nearest work of defense.

The amount of revenue collected during the eleven months ending May 31, 1885, was $15.95. During the same period the value of the imports was $80, and of the exports $125.

Ten vessels, with an aggregate tonnage of 360 tons, entered, and twelve vessels, with an aggregate tonnage of 395 tons, cleared.

The above is the latest report received. The office of deputy collector for the port was abolished in 1885.

In further compliance with terms of circular letter from the office of the Chief of Engineers, U. S. Army, dated September 29, 1888, I have to respectfully submit estimate of cost of survey, as follows:

FIELD WORK.

Services of an assistant engineer, say 25 days, at $160 per month	$133.33
Services of leadsman and rodman, say 25 days, at $90 per month	75.00
Services of two laborers, as boatmen and axmen, say 25 days, at $2 per day each	100.00
Hire of two boats, at $1 each per day, say 20 days	40.00
	348.33

OFFICE WORK.

Services of assistant engineer, 30 days, making estimates, profiles, maps, plotting, etc., at $160 per month	160.00
Total	508.33

This survey should be made as soon as possible if it is to be made this winter.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. Henry L. Abbot, Corps of Engineers, Division Engineer, Northeast Division.)

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[Fourth indorsement.]

U. S. ENGINEER OFFICE,
Cleveland, Ohio, November 24, 1890.

Respectfully returned to the Chief of Engineers, U. S. Army, through Col. H. L. Abbot, Division Engineer.

Within the past few days I have received a communication from Mr. S. B. Dick, president of the Pittsburgh, Butler and Shenango Railroad Company, stating that the company which he represents expects to extend its lines to Conneaut Harbor, Ohio, for a lake terminus; that they are laying track at the rate of a mile per day; that they expect to make a connection with the "Nickel Plate Railroad," at a point 10 miles from Conneaut Harbor, by January 1, 1891; that they expect to complete to Conneaut Harbor not later than June 1, 1891; and intend working at their terminal at Conneaut Harbor this winter.

In view of the above I am of the opinion that Conneaut Harbor, Ohio, is worthy of further improvement, as the prospective demands of commerce justify such expenditure.

L. COOPER OVERMAN,
Major of Engineers.

[Fifth indorsement.]

NORTHEAST DIVISION, ENGINEER OFFICE,
New York, November 26, 1890.

Respectfully returned to the Chief of Engineers. The facts stated in the fourth indorsement show that "the construction of a railroad to communicate with the iron and coal regions" may now be expected at an early day, and I accordingly concur with Major Overman in thinking that this harbor is "worthy of improvement."

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A,
Engineer Northeast Division.

SURVEY OF CONNEAUT HARBOR, OHIO.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 10, 1891.

GENERAL: I have the honor to transmit herewith, in separate package, a chart* (tracing) of Conneaut Harbor, Ohio, and to submit the following report of a survey of said harbor in accordance with letter dated office of the Chief of Engineers, U. S. Army, November 29, 1890.

Conneaut Harbor, Ohio, is situated at the mouth of a creek of the same name, about 30 miles west of Erie, Pa., and 13 miles east of Ashtabula, Ohio, near the boundary line between the States of Pennsylvania and Ohio.

Conneaut Creek, although a narrow stream, drains a large watershed and presents a depth of 15 feet and over after coming inside the shore line. Considerable current is usually found and the volume of discharge is equal or greater than that of most streams of similar width and depth. The banks are firm and the valley near the harbor would afford excellent room for docks for storage of ore and coal.

The attention of the General Government was first called to this locality for construction of a harbor in 1829, when there was a depth of only 2 feet across the bar at mouth of the stream. Since that date ap-

* Not printed.

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propriations amounting to a total of $112,629.39 have been expended on the harbor, a large part being for repairs to maintain the structures during fifty years.

The last appropriation was that provided by the act of June 4, 1880, and was $6,000 "for repairs." The appropriations were irregular and intermittent, with many suspensions, so that the plans for the improvement of the harbor, as projected, were never carried to completion. The best channel depth ever obtained was 11 feet at entrance, the usual depth being 8 feet.

The commerce seeking the harbor has always been small, and it is fair to conclude that the hopes entertained for this harbor when its improvement was undertaken were never realized, mainly for want of railroad communication direct from the harbor to the coal regions and iron furnaces south of the harbor.

The failure to attract an adequate commerce to the harbor led Congress to omit from the regular appropriation bills during the past ten years any allotment for Conneaut Harbor, Ohio, and since 1881 nothing has been done towards keeping the harbor in repair. It is now virtually destroyed, and the channel entrance closed by a sand bar. The piers have rotted down and been destroyed by the storms so as to be practically useless. The stream, following its natural bent, has broken a passage through the east pier, flowing to the eastward, instead of flowing northward through channel provided by the piers. A large deposit of sand, etc., from the lake storms has choked the channel between the piers.

At present there is neither town nor harbor, nor any commerce save some small fishing vessels which frequent the old harbor to discharge small quantities of fish for local consumption. Very extensive repairs and renewals, together with a large expenditure for dredging, would be necessary to restore the harbor as it was and give the 12-foot channel depth heretofore sought.

From a consideration of the data obtained it is considered that it will be as economical to ignore the old piers and build new, as to rebuild the old piers on old lines; such a change would also enable us to make new and better location of the piers, and this is very necessary if Conneaut Harbor is to be improved to accommodate the class of vessels which now are employed in the commerce of the lakes.

The additional or extra dredging rendered necessary by relocation of the piers would not be much, as the widening and deepening of the present channel would necessitate the removal of at least one pier entirely, and considerable of the structure of the other pier, to straighten the channel; and the portion of the pier which is left would require to be strengthened and sustained by piling to prevent undermining when depth of channel is dredged to 18 feet, as the piers were founded for only 12 feet channel depth.

SCHEME A (SEE TRACING).

To widen and deepen the existing old channel at Conneaut Harbor to secure 17 feet depth and 160 feet width between piers, extending from 17 feet natural depth in lake to inside the shore end of the old piers as at present located, would incur the following expenditure, approximately estimated:

To repair and partly rebuild the present west pier (the best), say	$36,000
To construct a new east pier to replace old pier, to be same length as existing west pier, say 1,200 linear feet, at $70 per linear foot	84,000

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To construct the additional length of piers to 17 feet natural depth in lake, say an extension of 800 feet for each pier, or for both 1,600 linear feet, at $75 per linear foot	$120,000
The piers to be 200 feet apart, with full channel width of 160 feet, and 17 feet channel depth. Dredging required for 160 feet width from 17 feet natural depth in lake to inside, say 2,100 feet, will require the removal of—	
100,000 cubic yards of soft material, at 18 cents	18,000
35,000 cubic yards of stones and gravel, at 30 cents	10,500
20,000 cubic yards of bowlders, etc., at 50 cents	10,000
Revetment inside of shore line for 500 linear feet on the west side and 700 linear feet on the east side, a total of 1,200 linear feet, at $10 per foot	12,000
	290,500
Contingent expenses, at least 15 per cent	43,575
Total	334,075

SCHEME B (SEE TRACING).

To relocate the channel and construct new piers will incur the following expenditure, approximately estimated:

To construct two new piers of the same length as the old piers, say 1,200 feet each, or 2,400 linear feet of piers, at $75 per linear foot	$180,000
To construct the additional length of piers to 17 feet natural depth in lake, say an extension of 800 feet for each pier, or for both 1,600 linear feet, at $75 per linear foot	120,000
Dredging new channel from 17 feet natural depth in lake to inside, for bottom depth of 160 feet, length say of 2,100 feet, will require the removal of—	
120,000 cubic yards of soft material, at 18 cents	21,600
50,000 cubic yards of stones and gravel, at 30 cents	15,000
30,000 cubic yards of bowlders, etc., at 50 cents	15,000
Revetment inside of shore line, 500 linear feet on the west side and 700 linear feet on the east side, a total of 1,200 linear feet, at $10 per foot	12,000
	363,600
Contingent expenses, at least 15 per cent	54,540
Total	418,140

It will be seen from the above that the difference in cost, per the approximate estimates, between the two plans for improvement is small when compared with the total cost of either plan, and too small not to make it advisable to adopt the plan which provides for the relocation of the channel and construction of two new piers throughout.

A line of railroad to Conneaut Harbor for a lake terminus is being constructed, and the grading, it is reported, will be finished by the end of this year to within 2 miles of the harbor.

With a line of railroad from the coal regions of Pennsylvania to Conneaut Harbor, the commerce of this harbor will rapidly increase and harbor be frequented by vessels of the larger class by which lake commerce is now transported. This will render the reconstruction of this harbor necessary, and on plan in accordance with present requirements.

With a line of railroad assured, I am of the opinion that the relocation of the harbor and the widening and deepening of the channel is a worthy improvement, and the prospective demands of commerce call for the improvement.

Conneaut is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the sixth order upon the bank of lake near mouth of creek, the light-beacon having been removed from end of pier on account of the dilapidated condition of the piers.

Fort Porter, New York, 100 miles distant, is the nearest work of defense.

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The amount of revenue collected during the eleven months ending May 31, 1885, was $15.95. During the same period the value of the imports was $80 and the exports $125.

Ten vessels, with an aggregate tonnage of 360 tons, entered; and twelve vessels, with an aggregate tonnage of 395 tons, cleared.

The above is the latest report received. The office of deputy collector for the port was abolished in 1885.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. Henry L. Abbot, Corps of Engineers, Division Engineer, Northeast Division.)

[First indorsement.]

NORTHEAST DIVISION ENGINEER OFFICE,
New York, November 14, 1891.

Respectfully forwarded to the Chief of Engineers, U. S. Army.

In view of the favorable location of Conneaut Harbor for the iron and coal trade, and of the construction of a railroad, now well advanced, to develop its natural advantages, I consider the harbor to be worthy of improvement.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
Engineer Northeast Division.

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APPENDIX N N.

IMPROVEMENT OF ERIE HARBOR, PENNSYLVANIA, AND OF DUNKIRK, BUFFALO, WILSON, OLCOTT, AND OAK ORCHARD HARBORS, AND OF TONAWANDA HARBOR AND NIAGARA RIVER, NEW YORK.

REPORT OF MAJOR E. H. RUFFNER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Erie Harbor, Pennsylvania.
2. Preservation and protection of Presque Isle Peninsula, Erie Harbor, Pennsylvania.
3. Dunkirk Harbor, New York.
4. Buffalo Harbor, New York.
5. Tonawanda Harbor and Niagara River, New York.
6. Wilson Harbor, New York.
7. Olcott Harbor, New York.
8. Oak Orchard Harbor, New York.

EXAMINATION AND SURVEY.

9. Port Day, above Niagara Falls, New York.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., July 7, 1892.

GENERAL: There are forwarded herewith the annual reports for the year ending June 30, 1892, for the harbors of Erie, Pa.; Dunkirk, Buffalo, Wilson, Olcott, and Oak Orchard, N. Y.; and for Tonawanda Harbor and Niagara River, New York.

* * * * * * *

Very respectfully, your obedient servant,

E. H. RUFFNER,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. Army.

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N N 1.

IMPROVEMENT OF ERIE HARBOR, PENNSYLVANIA.

Object.—The object of this improvement is twofold:

1. To protect the harbor from severe winds from the east and northeast.

2. To obtain and maintain a channel between deep water in the harbor and the open lake, 16 feet at low water and of navigable width.

Project.—The project, as originally prepared in 1823 and approved in 1824 (at which time the entrance to the bay was narrow and tortuous and only 6 feet in depth), provided for closing all of the eastern end of the harbor by means of a breakwater, in which should be left an opening 200 feet wide, and for extending to deep water in the lake two parallel piers, one on each side of the opening. This project is substantially in force at the present time, excepting that the piers are 350 feet apart.

Present works.—The present works consist of (1) a breakwater lying north and south from the main shore to the south side of the entrance to the harbor; (2) a pier on the south side of the entrance channel nearly east and west in position; (3) a pier on the north side of the channel parallel with and 350 feet distant from the pier before mentioned, and (4) a catch-sand jetty, built in 1883, about 3,000 feet north of the north pier, for the purpose of arresting the movement of sand into the channel. The construction of this jetty is such that it does not serve the purpose for which it was built, and it has received no repairs since its construction. These works are known as (1) the south breakwater, (2) the south pier, (3) the north pier, and (4) the catch-sand jetty.

The piers and breakwater consist of timber crib-work, filled with stone and covered with pine-plank deck.

The catch-sand jetty consists of a single row of piles driven close together and bound together with oak walings.

OPERATIONS DURING THE FISCAL YEAR.

Repairs to piers and breakwater.—Between stations 14 and 15 on the north pier six courses of superstructure on channel face of pier were removed and new deck built; 60 decayed deck plank replaced with new; 600 linear feet of waling repaired and oak fenders placed along 150 feet of the pier to provide a landing for harbor tugs. On the south pier minor repairs were made to the deck, and to the superstructure at the junction with the south breakwater. Repairs were begun on July 13 and completed on August 10, 1891.

Dredging in channels.—No dredging was done in the inner channel, nor needed, notwithstanding the extreme low stage of water which prevailed during the season of 1891. In the outer channel the point of the bar, lying along the pier extension recently constructed, was removed in June, 1892. This work was done by Hingston, Rogers & O'Brien, Buffalo, N. Y., at 18 cents per cubic yard, scow measurement. Dredging was begun on June 10 and completed on June 15, the bar being removed to a depth of 18 feet at low water. The quantity of material removed, being sand, was 2,800 cubic yards.

Surveys.—A survey of the east end of the peninsula and approach to the harbor entrance was made October 12 to 28. A map of this survey was compiled and completed on March 17, 1892. Examinations of the

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channels were made monthly and the water gauge tested frequently and maintained in good order.

Extension of the north pier.—The extension of this pier eastward into Lake Erie 450 feet, more or less, under contract of J. B. Donnelly, Oswego, N. Y., was begun in June, 1891. The contractor carried on his work energetically and completed his contract on October 2, 1891. The total length of the extension was 452.15 feet. The cost of the extension was $32,025.77, or $70.83 per lineal foot of completed pier.

Surveillance of the peninsula.—The watchman was on duty during the entire year. He enforced the rules in regard to the building of fires and cutting of trees or any growth on the peninsula, so far as possible over so large an area (about 4 square miles). No depredation was committed.

Fires occurred on the peninsula as follows: Two small fires on the bay shore on August 30, 1891, extinguished before any damage was done; a fire in marsh grass on the bay shore of the "neck," on October 18, 1891, burned over 20 acres of marsh, but was extinguished before any damage was done to large growth; a fire in large hemlock on the bay shore at "Big Bend," on April 24, 1892, burned trees over an area of 100 feet square, before the fire could be extinguished. In addition to his duties on the peninsula, the watchman maintained a careful watch over the public property stored in the boathouse and warehouse, and acted as engineer of the steam launch.

CONDITION OF THE WORKS.

South breakwater.—This structure is old and much decayed. Its total length is 2,024 feet; height above mean lake level, 1½ feet; width, 6 to 12 feet. No repairs were made during the year. At the close of the year the structure was intact and no repairs urgently needed.

South pier.—Length of this pier is 1,220 feet. The pier is in fair condition, but the timbers of the superstructure are becoming soft and show decay. At the junction of the pier and south breakwater some of the stone filling has been washed out and should be replaced. To do this will cost about $50.

North pier.—This pier is 2,437 feet long, having been extended 452 feet during the year. The westerly 993 feet of the pier is old, but with repairs to the deck, costing about $250, it can be put in fair condition. The remainder of the pier, 1,444 feet long, is in good condition, requiring only minor repairs, which will cost about $200.

Catch-sand jetty.—About 450 feet of the jetty remain intact but it is not considered worth repairing.

The channel.—The total length of the channel, from the 18-foot contour at low water in the lake to the same contour in the harbor, about 7,100 feet, is made up as follows:

	Feet.
From 18-foot contour at low water in the lake to the east or outer end of the north pier, outer channel	1,250
Between piers	2,450
From west or inner end of piers to 18-foot contour at low water in harbor, inner channel	3,400

The width of the channel when completely clear is 300 feet. A length of channel of 2,000 feet, lying between the piers, is kept thoroughly scoured out by the strong currents which run in and out and thus maintain the good condition at all times. The outer and inner channels require repeated dredging in order to maintain them at the required depth. No dredging was done in the inner channel throughout the year. At the close of the year it was in good condition, the depth of

water being 18½ to 20 feet at mean lake level, or not less than 17 feet at low water, for a width of 275 feet. A point of the bar above the north pier which encroaches upon the north half of the outer channel along the pier extension, built during the first half of the year, was removed by dredging in June, 1892. At the close of the year the outer channel was also in good condition, being 18½ to 20 feet deep at mean lake level, or not less than 17 feet at low water, for its entire width of 300 feet.

DOCK LINES.

A brief description of the manner of locating docks at Erie Harbor is given in the Annual Report of the Chief of Engineers for 1891, page 2874. No new docks were built during the year, but the increasing demand for dock room will probably lead to dock extensions in the near future. This fact emphasizes the advisability of establishing a dock line along the city front.

PROPOSED OPERATIONS.

Repairs to piers and breakwaters.—No repairs are necessary on the south breakwater at the close of the year. The repairs required on the south pier, consisting of the replacement of about 20 cubic yards of stone filling and strengthening of the pier at the junction with the south breakwater, will be made during July, 1892. Repairs needed in the easterly half of the north pier, consisting of the closing of a hole in the crib-work with sheet piling, the replacement of about 25 cubic yards of stone filling, and the renewal of 50 decayed deck plank will be made during July, 1892. The superstructure of the westerly 993 feet of the north pier is fast becoming weak. Its entire renewal will be necessary in the near future. It can be placed in fair condition for a year or two by patching the deck and fender piles and walings. It is proposed to make these repairs during July, 1892. The total cost of the above repairs is estimated at $500.

The cost of rebuilding the superstructure over the westerly 993 feet of the pier, renewing fender piling, oak walings, and mooring piles is estimated at $20,000.

Dredging.—Sand bars are liable to form suddenly across the harbor entrance during storms from the northeast. Should there be any serious filling in of the outer channel due to these storms the dredging necessary to clear the channel will be done promptly.

Extension of the north pier.—The existing project provides for the extension of this pier to a depth of 16 feet in the lake. To complete the project would require a further extension of 300 feet, and in order to check the rapid encroachment of the bar above the pier upon the channel this extension should be made as soon as possible and as funds become available. The cost of the extension would be 300 feet of pier, at $80 per foot, $24,000.

REMARKS.

The bar formation above the north pier continues to grow and encroach upon the pier. At the close of the year the shore line of the bar was at station 12 + 10, 997 feet from the end of the pier, showing no advance lakeward; but the bar had risen above water, forming a continuous shore line northward to the easterly point of the peninsula and adding another permanently closed pond to the peninsula formation.

Another bar formation, about 600 feet outward from the present shore line, is developing. In consequence, the gradual shoaling eastward toward the end of the pier will continue and eventually necessitate further extension of this pier. The extension of the south pier, as provided for in the existing project, is not deemed necessary or advisable under existing conditions. To complete the project would require an extension of 1,000 feet, at a cost of $65,000.

Proposed operations may be confined, therefore, to the extension of the north pier, repairs to piers and breakwater, and dredging in the channels.

The amounts needed for repairs and dredging can not be definitely stated, as damages by storms are liable to occur at any time. Provision should, however, be made for emergencies. I would therefore estimate the needed and possible expenditures for the coming year as follows:

Extension of north pier	$24,000
Rebuilding of superstructures	20,000
Repairs to piers and breakwaters	5,000
Dredging in channels	5,000
Total	54,000

Money statement.

July 1, 1891, balance unexpended	$70,106.13
Received from sales of material	4,716.89
	74,823.02
June 30, 1892, amount expended during fiscal year	37,131.23
July 1, 1892, balance unexpended	37,691.79
July 1, 1892, outstanding liabilities	504.00
July 1, 1892, balance available (includes $20,000 reserved for Presque Isle)	37,187.79
Amount appropriated by act approved July 13, 1892	40,000.00
Amount available for fiscal year ending June 30, 1893	77,187.79
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	54,000.00

COMMERCIAL STATISTICS.

Arrivals and departures of vessels for the year ending December 31, 1891.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steam	908	1,022,507	41	3,176	915	1,033,960	40	3,917
Sail	249	138,897	16	2,515	253	137,000	15	1,624

Greatest draft of vessels, 16½ feet.
Decrease of tonnage, 1891 under 1890, 74,108.

Amount of revenue collected, fiscal year ending June 30, 1891	$21,250.22
Value of foreign imports	67,095.92
Value of foreign exports	2,239.50
Enrolled tonnage, port of Erie, 1891	25,444.60
Enrolled tonnage, port of Erie, 1892	24,214.99
Decrease, 1892	1,229.61

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IMPORTS BY LAKE.

[Tons of 2,000 pounds.]

Articles.	Year ending December 31—					
	1886.	1887.	1888.	1889.	1890.	1891.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Merchandise	17,770	13,488	15,782	36,657	42,857	21,611
Limestone	3,360			6,000	24,414	14,333
Stone				17,640		4,668
Plaster				2,433	9,295	15,169
Lath	428	338	460	540		352
Shingles			100		116	
Produce					5	3
Stave bolts					2,488	1,500
Ice					4,700	
Copper					3,523	
Phosphates					500	
Barley	1,689	1,970	2,383	2,138	2,644	1,922
Corn	41,670	10,000	46,083	98,230	200,721	58,720
Oats			1,090	8,823	80	2,905
Wheat	34,360	45,062	9,530	33,815	45,354	206,152
Rye				2,815	6,888	17,440
Flax seed	13,925	3,104	2,836	250	1,500	14,690
Flour	133,310	91,985	96,935	152,225	143,428	97,198
Lumber	14,466	6,900	16,809	22,500	20,379	14,249
Pig iron	1,734	8,521	12,477	2,464	11,507	5,175
Iron ore	102,208	235,658	269,250	417,270	554,403	441,669
Total	364,920	416,976	473,735	804,800	1,033,796	917,757

EXPORTS BY LAKE.

[Tons of 2,000 pounds.]

Articles.	Year ending December 31—					
	1886.	1887.	1888.	1889.	1890.	1891.
Coal:	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Anthracite	107,406	157,083	279,400	258,534	332,666	470,716
Bituminous	127,849	73,762	125,848	151,869	234,266	176,704
Pig and manufacturing iron	4,900	397	1,262		4,017	
Merchandise	78,490	93,228	119,206	88,600	127,074	109,030
Tar and oil					1	2
Stone					1,836	
Timber					400	
Total	318,645	324,470	525,716	499,003	700,260	756,452

N N 2.

PRESERVATION AND PROTECTION OF PRESQUE ISLE PENINSULA, ERIE HARBOR, PENNSYLVANIA.

This peninsula forms the harbor of Erie, which is a land-locked bay about 5 miles long, having a maximum width of 1½ miles. The peninsula is a low sand formation about 6 miles long, varying in width from 300 feet at the "neck," which is nearly 2 miles long, and joins the body of the peninsula to the mainland at its western end, to 1½ miles at its widest part. The preservation of the peninsula is of vital importance to Erie Harbor, and it is for the purpose of preserving the harbor that the protection of the weak parts of the peninsula formation has been deemed necessary. The weak portion is the long narrow neck at the western end. The object for which all the works of protection have been constructed is the prevention of a breach through this narrow neck. This danger exists during severe storms from the westward.

At the present time no works exist excepting a few dilapidated pile

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jetties no longer of service, and the main line of piles, mattresses, and stone ballast on mattresses, of the shore protection partially constructed in 1889. No severe storms occurred during the year excepting during the winter, when the shores were well protected by ice. The "neck" remains intact, and at its normal width and height above water level. A slight accumulation of sand along the protection work constructed in 1889 is noticeable.

Along the lake front, extending a mile or more west from the flash light-house the gradual wearing away of the bank continues, but as the peninsula is here one-half mile or more wide, the safety of the harbor is not threatened at this point. There was no work done on any of the protection works during the year. A report of the Board of Engineers on the construction of shore protection for the peninsula at Erie Harbor, Pennsylvania, was published in the Annual Report of the Chief of Engineers, for 1890, page 2800. In accordance with the recommendation of the Board and the approval of the Chief of Engineers, no expenditure will be made at present to protect the "neck" of the peninsula on its lake side, and $20,000 of the funds available for the improvement of Erie Harbor are reserved to close any breach which may occur in the neck of the peninsula.

Commercial statistics.—The commercial statistics are the same as those submitted for Erie Harbor.

N N 3.

IMPROVEMENT OF DUNKIRK HARBOR, NEW YORK.

Object.—The object of this improvement is to form an artificial harbor in the indentation of the shore line of Lake Erie, in front of the city of Dunkirk, N. Y.

Project.—The original project was adopted in 1827, and with its subsequent modifications provided for the construction of a pier running out from the west shore of the indentation, and a detached breakwater parallel with the pier and about 2,000 feet distant from the city front. An opening between the two structures provided a harbor entrance, through which a channel leading to the docks was to be deepened to 13 feet. By 1832, the sum of $28,439.84 had been expended on the original plan, and a breakwater was then 2,564 feet long, and the pier 1,400 feet long. Subsequently various improvements and repairs were made. In 1848 the breakwater was demolished.

In 1870 the question of the improvement of this harbor was referred to a Board of Engineers. The Board recommended a plan which provided for a detached breakwater 2,860 feet long, one part of which, 2,300 feet long, was to be nearly parallel with the shore, the other part to be nearly parallel with the axis of the channel entrance, 560 feet long, and terminating at the position of the dumb beacon. This breakwater, with the pier already built, was to form the harbor, and the old channel was to be enlarged to 170 feet wide and 13 feet deep. This project is in force at the present time.

Present works.—The present works consist of an unfinished detached breakwater 1,341 feet in length, a part of the 2,300-foot section provided by project; a pier 1,410 feet long, exclusive of the light-house crib, and a channel 100 feet wide and 12 to 14 feet deep. The breakwater and pier consist of timber work, the cribs being filled with stone and decked over.

Operations during the fiscal year.—At the beginning of the year a contract was in force with Gustavus C. Grimard, Buffalo, N. Y., for

rebuilding 150 feet of superstructure at the west end of the breakwater, building and placing one crib and 170 feet of new superstructure at the east end of the west pier, westward from the beacon, and tearing down and rebuilding an additional 50 feet of superstructure where most needed.

The contractor began operations on July 27, 1891, and by the time his contract expired on December 1, 1891, had not fully completed the construction of the 170 feet of superstructure at the east end of the west pier. In order to complete this portion of the work, and render it secure for the winter, an extension of time of contract to January 1, 1892, was granted. Under this extension the contractor was able to complete the section by December 20. No work was done on the breakwater or other parts of the pier, and on January 1, 1892, the contract was abandoned. Owing to extreme low water prevalent during the season of 1891, there was but 10 feet of water on the inner and outer bars in the channel. Vessels experienced much trouble in getting around in consequence. In order to relieve navigation as much as possible the dredge *Hingston & Woods, No. 6*, was employed to dredge out the bars to a depth of 13 feet. Dredging operations were begun on October 2 and completed on October 10. The total quantity of material dredged was 2,900 cubic yards, at a cost of $665, or about 23 cents per cubic yard, scow measurement.

CONDITION OF THE WORKS.

Breakwater.—The superstructure for a distance of 200 feet at the west end requires extensive repairs, 100 feet thereof must be entirely rebuilt. The remainder of the structure, 1,141 feet in length, remains intact, though much decayed, and requires minor repairs to the slope.

West pier.—The 420 linear feet at the west or shore end are buried in the sand and need no longer be kept in repair. The next, following, 724 feet of pier, is in a wrecked condition and requires new superstructure. The next, following, 90 feet, are nearly new, but the crib wall on the lake side for a length of 30 feet is gone and stone filling washed out to a depth of 5 feet under water. The remainder of the pier to the beacon, viz, 170 feet, is new and in good condition.

The channels.—The channel to be maintained is about 2,800 feet long, extending from the 14-foot curve in the lake to the city docks, 170 feet wide and 13 feet deep. At the close of the year the channel was 100 to 150 feet wide and not less than 12 feet deep. Filling in takes place rapidly on account of the littoral currents carrying the sand across the channel to the outer bar. Against this the existing works afford no protection.

PROPOSED OPERATIONS.

The rebuilding and repair of superstructure on the breakwater and pier should be made as rapidly as funds become available. The cost of this work is estimated as follows:

Rebuilding 100 feet of superstructure in breakwater	$4,000
Rebuilding 724 feet of superstructure in piers	28,960
Repairs to breakwater	500
Repairs to piers	500
Total	33,960

The estimate for repairing existing structures is less than one-third of former estimates and is based on the opinion that the structures will endure with minor annual repairs, for some years in fair condition.

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The work to be done to complete the existing project is estimated to cost about $170,000. The estimate is given in detail in the Annual Report of the Chief of Engineers for 1891, page 2880. It is important that the existing structures should be put in at least a fair condition before the work to be done to complete the project is begun. Of the latter work to be done, the construction of the arm of the breakwater, 560 feet in length along the eastern edge of the channel would no doubt be of the first importance, as it would afford needed protection to the channel.

The proposed application of the appropriation asked for, for the fiscal year ending June 30, 1894, is the continuation of needed renewal and repair of existing works, dredging in channel, and continuation of the existing project.

Money statement.

July 1, 1891, balance unexpended	$20,926.33
June 30, 1892, amount expended during fiscal year	6,864.93
July 1, 1892, balance unexpended	14,061.40
July 1, 1892, outstanding liabilities	7.00
July 1, 1892, balance available	14,054.40
Amount appropriated by act approved July 13, 1892	20,000.00
Amount available for fiscal year ending June 30, 1893	34,054.40
Amount (estimated) required for completion of existing project	128,116.41
Amount that can be profitably expended in fiscal year ending June 30, 1894	34,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and departures of vessels, compiled by the Collector of Customs, Dunkirk, N. Y.

Class.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers	25	5,039	3	980	26	5,156	2	961
Sailing vessels	17	5,233	3	1,024	18	5,398	2	654
Total	42	10,272	6	2,024	44	10,554	4	1,615

Increase of tonnage over season of 1890, 1,969 tons.
Amount of revenue collected during the year ending December 31, 1891, $1,683.87.
Greatest draft of vessels, 12½ feet.
Value of imports same year, $24,287.97.
No new lines of transportation established.

N N 4.

IMPROVEMENT OF BUFFALO HARBOR, NEW YORK.

Object.—The object of the improvements is to protect the entrance to Buffalo Harbor, protect the shore south of Buffalo Creek, and to form an outer harbor of refuge where vessels may lie in safety.

Project.—From 1819 to 1874 various projects, with their modifications, were submitted, and such as bear the approval of the War Department

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provide for the following works, to wit: North pier, south pier, masonry sea wall, sand catch or pile pier, and breakwater and shore arm.

The north and south piers are at the entrance to Buffalo Creek. The sea wall beginning at the south pier extends southward along the lake shore. The sand catch extends from the shore into the lake at a point about 8,000 feet southward of the south pier. The breakwater, commencing about on the line of the south pier extended, lies on a line parallel with the shore about one-half of a mile from it, and when completed will extend from the line of the south pier southward for a distance of 7,600 feet. The shore arm of the breakwater is intended to cover the opening between the south end of the main breakwater and the shore, leaving a passageway for vessels.

All of the above-mentioned works have been constructed, except 800 feet of the main breakwater, and the shore arm, and 220 feet of the sand catch.

The breakwater, as originally built, consisted of a substructure composed of separate timber cribs filled with stone, and a continuous superstructure of timber crib work filled with stone. The present project contemplates the reconstruction of decayed or wrecked superstructure, substituting solid concrete in place of timber crib work. In the prosecution of the work of reconstruction of the breakwater a considerable plant has been accumulated, consisting of steamboat, scows, steam derricks, engines, concrete machinery, etc.

For the accommodation of this plant and large quantities of material, authority has been granted for the building of a dock with storage ground on the lake front south of the south pier.

Operations during the fiscal year.—At the beginning of the year work was in progress, setting concrete blocks and getting machinery ready for mixing and carrying concrete. On July 4 a heavy gale washed 362 blocks, each weighing about 7 tons, from the breakwater. With the help of a diver the blocks were all recovered, the last having been raised August 23. The laying of the concrete began August 4, and was practically finished October 12. An experimental top parapet 300 feet long, 5 feet high, was begun October 17 and finished on the 19th. All top dressing was finished November 8. Prior reports describe machinery and method of construction, and it remains to note that a great volume of concrete was quickly and successfully laid, the cable road being a perfect success, and previous experience having led to skill and promptness in the details of construction. The length of the concrete-superstructure built during the season is 1,967.9 feet. The volume of the concrete is 25,969.28 yards, the cost $213,165.69. This makes the cost per running foot $108.32, and per cubic yard $8.21. In 1889 this cost was $110.19 per foot, and $9.19 per cubic yard.

Experience and improved arrangement of the machinery, and especially the moving of cars by cable instead of by hand, account for the less cost.

The work on the extension of the breakwater was well started at the end of last year; the first crib was sunk July 17; the last crib, September 23; and the superstructure finished November 9. The length of the extension is 452.6 feet; the total cost, including the inspector, is $60,189.91, or $132.99 per running foot.

CONDITION OF THE WORKS.

Breakwater.—The concrete superstructure is in fine order, there being no settling or disintegration. The wooden superstructure for a

length of about 2,900 feet is in good condition, and will hold its own for several years to come with minor repairs each year. The total length of the breakwater is now 6,803.9.

South pier.—Has settled in some places, where too close dredging by the city about 8 years ago had undermined it. These places were repaired in 1887, but have settled again.

North pier.—The Delaware, Lackawanna and Western Railroad Company occupies this pier yet, notwithstanding the fact that the license for such occupation was revoked by the Secretary of War on February 20, 1891. It is understood that the Department of Justice will take the necessary steps to protect the interests of the Government in this matter.

Boathouse.—Is in fair condition.

No operations are proposed with funds on hand, they not allowing of sufficiently advantageous application. The next appropriation will be used in continuing the breakwater and in building more or less of the shore arm.

Money statement.

July 1, 1891, balance unexpended	$269,317.42
Amount received for cost of repair of damage to work	173.95
Repayment	16.70
Total	269,508.07
June 30, 1892, amount expended during fiscal year	230,604.08
July 1, 1892, balance unexpended	38,903.99
July 1, 1892, outstanding liabilities	15.00
July 1, 1892, balance available	38,888.99
Amount appropriated by act approved July 13, 1892	300,000.00
Amount available for fiscal year ending June 30, 1893	838,888.99
Amount (estimated) required for completion of existing project	146,223.17
Amount that can be profitably expended in fiscal year ending June 30, 1894	146,223.17
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

Arrivals and departures of vessels for the year ending December 31, 1891.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers	2,968	3,604,326	361	81,538	2,982	3,588,326	350	67,788
Barges	.....	.....	558	76,571	.....	.....	561	76,973
Sailing vessels	1,387	691,808	173	41,885	1,380	663,635	155	36,759
Total	4,355	4,296,134	1,092	199,994	4,362	4,251,961	1,066	181,520

Amount of revenue collected during the year ending December 31, 1891, $827,595.76.
Value of imports same year, $4,859,602.
Value of exports same year, $539,588.
Increase of tonnage in 1891, tons, 11,566.95.
Vessels enrolled at this port, 1891, 325.
Greatest draft of vessels, 16 feet.
New lines of transportation established, none.

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Receipts by lake for the years ending December 31, 1886, 1887, 1888, 1889, 1890, and 1891.

Articles.	1886.	1887.	1888.	1889.	1890.	1891.
Grain.						
Wheat.....bushels..	41,430,440	48,111,180	27,548,110	26,051,600	24,868,630	76,945,960
Corn.....do...	29,155,370	30,199,490	36,422,270	47,127,150	44,136,060	29,616,390
Oats.....do...	1,014,670	4,656,280	7,897,310	14,309,800	13,860,780	12,454,150
Barley.....do...	787,730	1,459,420	842,090	1,474,570	5,165,700	4,373,120
Rye.....do...	126,630	304,540	513,720	1,906,760	1,281,630	5,603,400
Flour (as grain)..do...	22,910,950	20,006,800	26,224,650	27,403,550	.....	35,466,700
Totals.....	95,425,790	104,737,710	99,448,150	118,273,430	.....	164,459,720
Flour.....barrels..	4,582,190	4,001,360	5,244,930	5,480,710	6,245,580	7,093,340
Lumber.						
Headings.....barrels..	75,000	.....	.....	.....	.....	.....
Hoops.....number..	424,000	47,200	.....	.....	548,000	.....
Lumber.....feet..	279,493,000	264,612,000	279,493,000	242,525,000	287,334,000	262,729,000
Lath.....pieces..	12,166,500	12,469,000	9,688,000	10,033,500	34,250,000	5,513,000
Railroad ties.number..	54,780	93,080	196,600	442,570	197,110	238,570
Staves.....do...	1,289,500	1,980,350	945,000	200,000	970,000	424,000
Stave bolts.....cords..	9,710	6,450	9,100	3,120	6,560	9,130
Shingles.....number..	58,582,000	36,705,000	58,582,000	36,331,500	73,500,000	44,905,250
Posts.....do...	255,000	7,000	4,600	15,000	48,000	89,950
Logs.....feet..	13,650,000	31,500,000	28,750,000	24,450,000	29,400,000	40,817,000
Other articles.						
Copper.....packages..	835	.....	.....	.....	.....	.....
Copper.....tons..	24,968	87[illegible]11	28,164	28,853	40,436	50,934
Copper, cakes and bars.	35,663	6,000	.....	.....	.....	16,420
Flaxseed.....bushel..	3,056,010	2,342,660	753,890	4,420,670	2,681,880	6,322,490
Feed.....sacks..	386,570	404,790	774,280	810,720	1,024,700	1,188,250
Iron ore.....tons..	28,430	30,760	248,850	298,060	551,940	421,890
Iron, pig.....do...	15,510	119,780	23,220	36,400	35,910	30,730
Lead.....pigs..	106,770	195,590	116,820	265,130	424,550	507,970
Lard.....packages..	193,810	103,750	132,040	217,520	385,770	103,560
Oil cake.....do...	230,230	106,520	184,730	301,340	255,550	204,350
Pork.....barrels..	31,550	26,960	30,860	41,180	55,900	48,210
Seed.....bags..	71,690	22,700	19,300	72,080	50,250	51,930
Malt.....bushels..	.....	.....	.....	234,640	482,710	496,620
Wool.....bales..	.....	.....	.....	.....	36,900	145,690

Principal exports by lake, 1886 to 1889.

Articles.	1886.	1887.	1888.	1889.
Coal.....tons..	1,562,050	1,904,060	2,546,405	2,156,670
Cement and plaster.....barrels..	378,940	413,890	370,790	409,400
Salt.....do...	126,040	109,120	143,460	172,980
Salt.....tons..	2,635	8,942	4,115	1,082
Railroad iron.....do...	45,894	40,528	14,914	6,981

Principal exports by lake, 1890 and 1891.

Articles.	1890.	1891.
	Tons.	*Tons.*
Coal.....	2,157,810	2,436,330
Cement and plaster.....	105,794	94,748
Salt.....	21,115	21,215
Salt.....	2,637	1,913
Railroad iron.....	34,648	9,055
Total.....	2,321,643	2,563,261

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N N 5.

IMPROVEMENT OF TONAWANDA HARBOR AND NIAGARA RIVER, NEW YORK.

Object.—To provide a navigable channel from the entrance to the Niagara River at Lake Erie to the north end of Tonawanda Harbor.

Project.—To remove obstructions so as to make a channel 400 feet wide and 18 feet deep, which includes work at the following places:

1. On the reef known as Horseshoe Reef at the entrance of Niagara River.
2. On the shoal place at the head of Strawberry Island.
3. A few shoal places abreast of the lower end of Rattlesnake Island.
4. The full width of the river between Tonawanda Island or Whites Island and the main land along the entire front of Tonawanda.

This project was approved in 1888.

In addition to the above considerable work to be done in the channel near the city water works pier and a lately discovered shoal in the Horseshoe Reef Channel.

Operations during the fiscal year.—On May 30, 1891, bids were opened for removing rock, sand, gravel, and clay near Strawberry Island. The contract was awarded to Hingston & Woods, at $3.74 per cubic yard of rock excavation, measured in place, and 74 cents per cubic yard of sand, gravel, and clay dredging, measured in place. This contract has been carried out, and the contractors removed 9,086 cubic yards of rock and 4,324 cubic yards of sand, gravel, and clay. The result is a channel through the shoal 200 feet wide and 16 feet deep at mean-water level. The total number of cubic yards removed near Strawberry Island is 28,764.

The Horseshoe Reef shoal was removed by the hire of dredge and drill boat per day and 1,650 cubic yards were removed, and much additional pushed or rolled into deep water.

On May 20, 1892, bids were opened for removing obstructions in the Niagara River and dredging Tonawanda Harbor. The contract was awarded to Hingston & Woods, dredging clay at 21 cents per cubic yard, and sand, gravel, etc., 25 cents per cubic yard.

Money statement.

July 1, 1891, balance unexpended		$69,535.25
June 30, 1892, amount expended during fiscal year		40,392.86
July 1, 1892, balance unexpended		29,142.39
July 1, 1892, outstanding liabilities	$1,910.00	
July 1, 1892, amount covered by uncompleted contracts	25,000.00	
		26,910.00
July 1, 1882, balance available		2,232.39
Amount appropriated by act approved July 13, 1892		75,000.00
Amount available for fiscal year ending June 30, 1893		77,232.39

Amount (estimated) required for completion of existing project	1,008,690.16
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Arrivals and departures of vessels from Tonawanda Harbor, New York, season of 1891.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers	297	144,625	78	24,452	308	150,108	71	19,215
Sailing vessels	694	283,567	57	21,161	703	287,047	45	15,180
Total	991	428,192	135	45,613	1,011	437,155	116	34,395

The decrease of tonnage in 1890 was 176,227.
Revenue collected December 39, 1891, was $72,948.22.
Value of imports, same year, $300,182.
Greatest draft of vessels, 13 feet.
No new lines of transportation established.
Principal imports and exports, lumber.

N N 6.

IMPROVEMENT OF WILSON HARBOR, NEW YORK.

Object.—To obtain a 12-foot channel from Twelve Mile Creek to Lake Ontario.

Project.—The first project for this harbor was submitted in 1846. No action was taken on it. The second project, submitted in 1873, was to extend piers to the 12-foot curve in Lake Ontario, to dredge a channel, 12 feet deep, between the piers, and 100 feet wide from the shore end of the piers to the deep water in the creek.

Present works.—The present works are the east and the west piers, and a shore protection. The piers are the prolongation of piers built by private parties in 1846, and extend to the 12-foot curve in Lake Ontario. The shore protection joining the shore end of the east pier was built in 1888, and is 360 feet long. The channel has an available depth of 9.5 feet at mean lake level for a width of 100 feet from the west pier. During the fiscal year ending June 30, 1892, the lake end of the west pier has been repaired at a cost of $75.

CONDITION OF THE WORKS.

West Pier.—The pier needs repairs, as follows: Starting from the inland end, the first 200 feet is entirely rotten, and should be entirely rebuilt from the cribs; the next 150 feet is in good condition; the next 350 feet is much decayed at many parts, and in two places is much sunk out of line, dipping both to the east and to the west.

This last length should be rebuilt, at least from low water, and it may possibly be necessary to rebuild a part of the cribs, in order to level them off. The remainder of the pier is in good condition, except the extreme end, which was considerably damaged during the past few years. The end crib with superstructure should be rebuilt.

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East Pier.—This pier requires about 75 new planks to replace those decayed in its flooring in various places throughout its length. A portion of the west side should be rebuilt from the water line upward for a length of 50 feet, the present timbers being much rotted. It would be well also to sheath the end of this pier with plate iron.

Shore protection is in good condition.

The channel.—This is now in fairly good condition. It is available, at mean lake level, for vessels drawing 8.5 feet. The amount of rock developed in the course of the dredging, as required to be removed in order to obtain a full depth of water, was much greater than originally supposed. The latest examinations give the quantity to be taken out, in order to obtain a depth of 12 feet, as 4,200 cubic yards in place. The amount of dredging yet to be done is about 700 cubic yards in place. If this rock should be removed at any future time, it would be well to dump it along the lake sides of the piers.

Estimated cost of the work.—In order to complete the present project the following work is necessary—the removal of 4,900 cubic yards [in place] of material from the channel. This will cost—

In place:	
4,200 cubic yards rock excavation, at $3 per cubic yard	$12,600
700 cubic yards dredging, at 30 cents per cubic yard	210
Total	12,810
Contingencies, 10 per cent	1,281
Total	14,091

The necessary repairs to the piers are estimated to cost $13,364.20.

The total cost of the work that should be done to carry out the project is:

Opening the channel	$14,091.00
Repairs of piers	13,364.20
Total	27,455.20

This work can all be done in one season; if only one of the items be taken up, it should be the repairs of the piers. There being no funds on hand, nothing is proposed to be done.

Money statement.

July 1, 1891, balance unexpended	$100.25
June 30, 1892, amounted expended during fiscal year	78.76
July 1, 1892, balance unexpended	21.49
Amount (estimated) required for completion of existing project	27,455.20
Amount that can be profitably expended in fiscal year ending June 30, 1894	27,455.20

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Arrivals and departures of vessels for the year ending December 31, 1991.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers			39	9,282			39	9,282
Sailing vessels	1	280	3	213	2	319	5	355
Barges								
Total	1	280	42	9,495	2	319	44	9,637
Total, 1890	5	562	46	12,067	5	562	46	12,067

Amount of revenue collected during the year ending December 31, 1891, $103.90.
Value of imports same year, $2,419.
Value of exports same year, $678.
Decrease of tonnage same year, 5,527.
Vessels enrolled at this port, none.
New lines of transportation established, none.
Principal imports, lumber, shingles, and posts; principal exports, fruit.

N N 7.

IMPROVEMENT OF OLCOTT HARBOR, NEW YORK.

Object.—To obtain a protected channel 13.5 feet deep at mean lake level from Lake Ontario to the bridge crossing Eighteen Mile Creek at Main street.

Project.—The first project for this work was submitted in 1846, but it was not executed. The present project was adopted in June 18, 1891, and is substantially the project of 1866, with some enlargements. It provides for two piers extending into the lake with a channel between them. The piers are nearly parallel to each other, about 200 feet apart. The east pier is 850 feet long, and the west pier 873 feet. Between the piers the channel is about 180 feet wide, the limiting lines being 10 feet from the piers, and from the shore ends of the piers it decreases to 98 feet in width at the Main Street Bridge. The channel depth is 13.5 feet, measured from mean lake level.

Present works.—East and west piers, and the channel between them.

Operations during the fiscal year.—In the river and harbor act of 1890 the amount of $30,000 was appropriated for this harbor. Contracts were made with Ira Farnsworth for the repairing of the piers, and with Hingston and Woods for channel excavation. Both contracts have been carried out. The piers have been placed in a good condition at an expense of $8,991.87, and the channel has been excavated to the required depth at an expense of $15,213.48. Ten thousand two hundred and eighty-seven cubic yards of rock, at the rate of $1.24 per cubic yard, and 10,140 cubic yards of sand, gravel, and clay, at the rate of 24 cents, have been removed.

Condition of works.—Both piers are in good condition, and the channel has the full depth between the limits as given.

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Proposed operations.—The project for this harbor is completed, and the remaining funds will be used for maintenance.

Money statement.

July 1, 1891, balance unexpended	$30,296.94
June 30, 1892, amount expended during fiscal year	24,800.71
July 1, 1892, balance unexpended	5,496.23
July 1, 1892, outstanding liabilities	17.00
July 1, 1892, balance available	5,479.23

COMMERCIAL STATISTICS.

Arrivals and departures of vessels for the year ending December 31, 1891.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers	2	32	4	651	3	51	4	651
Sailing vessels	1	76	18	764	1	76	16	622
Total	1	108	22	1,415	4	127	20	1,273
In 1890	.....	.....	1	12	.....	.....	1	12

Amount of revenue collected during the year ending December 31, 1891, $371.21.
Value of imports same year, $4,229.85.
Value of exports same year, $1,820.15.
Increase of tonnage same year, 2,911.
Vessels enrolled at this port, none.
Greatest draft of vessels, 10 feet.
New lines of transportation established, none.
Principal imports, lumber; and principal exports, fruit.

N N 8.

IMPROVEMENT OF OAK ORCHARD HARBOR, NEW YORK.

Object.—To furnish a protected channel 200 feet wide and 12 feet deep from deep water in Lake Ontario to deep water in Oak Orchard Creek.

Project.—The original plan for this improvement, adopted in 1836, consisted in contracting the mouth of the creek to 200 feet by two breakwaters running from the shore, one on each side, and a channel between two parallel piers from the 12-foot curve in the creek to the same curve in the lake. This project, except as to the breakwaters, is still in force.

Present works.—The present works are the east and west piers and a shore protection. The piers extend to the 12-foot curve in the lake.

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The shore protection, beginning at the shore end of the east pier, was built in 1889, and is 91 feet long. The channel has a depth of 13.5 feet at mean lake level for the whole width between the piers, excepting 10 feet along each pier.

Operations during the fiscal year.—In the river and harbor act of 1890 the amount of $5,000 was appropriated for this harbor. Contract was made with Hingston & Woods to widen the channel at the rate of $1.40 per cubic yard for rock excavation and 34 cents per cubic yard for mud, sand, and gravel measured in place. Three thousand three hundred and eighty-eight cubic yards of rock and 350 cubic yards of mud, sand, and gravel have been removed, giving a channel of 13.5 feet depth below mean lake level.

Condition of the works.—The east pier and the shore protection are in good condition and need but slight repairs—a few planks for decking. The west pier has settled for a length of 130 feet about 2½ feet on the harbor side, where the pier intersects the shore line; also on the outer end toward the lake. Both settlements were caused by very rough weather in the fall of 1891, during the low stage of water, 2.2 feet below mean lake level, undermining those places. The channel is in good condition.

Proposed operations.—If the funds on hand allow it, the settled portion of the pier will be repaired. The project of this harbor has been completed, but a certain amount of money should be appropriated to keep it in repair.

Money statement.

July 1, 1891, balance unexpended	$5,485.79
June 30, 1892, amount expended during fiscal year	4,963.45
July 1, 1892, balance unexpended	522.34
July 1, 1892, outstanding liabilities	8.50
July 1, 1892, balance available	513.84

COMMERCIAL STATISTICS.

Arrivals and departures of vessels for the year ending December 31, 1891.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steamers	6	131			6	131		
Sailing vessels	1	76	4	692	4	586	1	182
Total	7	207	4	692	7	717	1	182
In 1890			5	250			5	250

Amount of revenue collected during the year ending December 31, 1891, $196.83.
Value of imports, same year, $2,282.
Increase of tonnage same year, 1,298.
Greatest draft of vessels, 10 feet.
New lines of transportation established, none.
Principal imports and exports, lumber, shingles, and posts.

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N N 9.

[Printed in House Ex. Doc. No. 67, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF PORT DAY, ABOVE NIAGARA FALLS, NEW YORK.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., February 28, 1891.

GENERAL: In accordance with the provision of the river and harbor act of September 19, 1890, directing an examination of Port Day, above Niagara Falls, and Department letter of September 20, 1890, assigning the examination to my charge, I have the honor to submit the following report of preliminary examination:

Port Day is the name given to the head, or entrance from Niagara River, of what is known at Niagara Falls as the Hydraulic Canal, and is about 2,000 feet above the head of Goat Island.

In November, 1880, an examination of this locality was made under the direction of Maj. Walter McFarland, and his report may be found in the annual report of the Chief of Engineers, U. S. Army, for fiscal year ending June 30, 1881, page 2454. From this report it will be learned that at the time of the first examination the improvement contemplated was to provide a safe water communication between Niagara Falls and Tonawanda, on the Niagara River, 10 miles above, where connection could be had with the Erie Canal. The improvement suggested in the report was the making of a good and secure channel through which canal boats drawing 5 feet of water could pass to Port Day, by making a cut close to the American shore through the rocky ledge forming the Schlosser Rapids, the estimated cost of which was $17,000.

After some correspondence with the authorities of Niagara Falls, my inquiries concerning the nature and extent of improvement contemplated and the demands of commerce for such improvement were referred to the Cataract Construction Company, who are engaged in the construction of the tunnel and works of the Niagara Falls Power Company. Upon meeting the resident engineer of the company, Mr. Albert H. Porter, at Niagara Falls, I was shown the plans of the company, and was informed that the improvement of river desired was to furnish a channel for the navigation of lake vessels to convey raw material to, and the manufactured products from, the extensive factories and works, in addition to those now existing, which it was expected would in the near future be established at Niagara Falls upon the completion of the development of the enormous water power now under way.

The plans upon which work is in progress are estimated to develop 120,000 horse power, which is said to be equal to the water power of

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Lawrence, Holyoke, Turners Falls, Manchester, Bellows Falls, Lewiston, Cohoes, Oswego, Patterson, Augusta, Ga., Minneapolis, Rochester, and Lockport combined. With this immense power developed, with no uncertainty concerning its continuance, and in a central and otherwise favorable locality, it would seem that a very large commerce must be soon built up which would justify very considerable improvements in the way of providing for cheap water transportation. This large prospective commerce, however, though it may be considered well assured, is in the future more or less distant.

At this present the commerce of Niagara Falls may be estimated by the following statement of annual output of manufacturing establishments as furnished by the Business Men's Association of Niagara Falls:

Articles.	Quantity.	Value.
Flour.....barrels..	942,000	$4,710,000
Paper and pulp.....tons..	9,156	527,520
Barrels	603,600	211,260
Blank books	.....	350,000
Beer.....barrels..	40,000	280,000
Other industries	.....	209,600
Total	.....	6,288,380

Twenty-seven thousand cars of mill freight are now handled every year.

From the above it will be seen that this locality is already a manufacturing center of no small importance, and with the greatly increased future importance which seems to be well assured to it, it appears to me to be a locality worthy of improvement with regard to its water communications.

Work now in progress on the upper part of the Niagara River will furnish a channel 16 feet in depth as far as Tonawanda, and from Tonawanda to a point near the head of Conners Island, about 2¼ miles above Port Day, there is shown on the lake survey chart a channel with a least depth of 11 feet, and for most of the distance a least depth of 14 feet. This channel is on the east side of Grand Island. A better channel exists on the west side of this island, but to reach Port Day from the latter channel would necessitate the crossing of the river at a point not more than 2½ miles above the falls, which is entirely too hazardous for the ordinary and constant use of a commercial highway.

An examination of the accompanying map, showing the soundings recently made by the Cataract Construction Company from Port Day up to a point above Conners Island, indicates that a navigable channel could be made on a line just inside of Grass and Conners islands at a comparatively small cost. Unfortunately, in the company's survey, borings were not made far enough out in the stream to show the nature of the bottom in the deeper water, but such borings as were made indicate that there is considerable gravel, and the bottom contours just inside of the two islands would seem to show that the gravel is of such depth that a good channel could be made without much rock excavation, except on the crossing of Schlosser Rapids. The current above and below these rapids is not of very great velocity, the water surface having a gentle slope, while in crossing the rapids it falls about 1 foot.

An embankment extending from Port Day to the foot of Grass Island, and from the head of the island to the head of the rapid, about 3,800 feet altogether, would give an additional depth of 1 foot below the rap-

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ids and make a safe entrance to Port Day. In my opinion it would be justifiable to make a survey at this locality to ascertain more definitely the water surfaces, and the nature of the bottom that would have to be excavated to provide a channel with a depth, say, of 13 or 14 feet. The survey should cover the distance from Port Day to deep water just above Conners Island, and a few points on the river above. The estimated cost of such a survey is $500. I am indebted to the courtesy of Mr. Albert Porter, engineer of the construction company, for a map* of soundings in the vicinity of Port Day, a copy of which is appended, together with a map* of the Niagara River from Tonawanda to Niagara Falls, enlarged from the lake survey chart.

Very respectfully, your obedient servant.

AMOS STICKNEY,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. Henry L. Abbot, Corps of Engineers, Division Engineer, Northeast Division.)

[Third indorsement.]

NORTHEAST DIVISION, ENGINEER OFFICE,
New York, March 10, 1891.

Respectfully returned to the Chief of Engineers, U. S. Army. It is my opinion that Port Day above Niagara Falls is worthy of improvement.

HENRY L. ABBOT,
Colonel of Engineers, Brevet Brigadier-General, U. S. Army,
Engineer Northeast Division.

SURVEY OF PORT DAY, ABOVE NIAGARA FALLS, NEW YORK.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., December 31, 1891.

GENERAL: I have the honor to submit the following report on the survey of Port Day above Niagara Falls, N. Y., and upon plans with estimates of cost for navigable channels to that point.

In my report of February 28, 1891, upon the preliminary examination of this locality, it was stated that the improvement desired was to furnish a navigable channel for lake vessels. In order to obtain the necessary data for planning such a channel, and for making estimates of cost, it was necessary to make a survey that would not only cover the immediate vicinity of Port Day, but several points on the river where the lake survey charts showed shoal places as far up as Tonawanda. Authority having been received for such a survey, a party was sent into the field under the charge of Mr. Ernest Siegesmund, assistant engineer. The principal part of the survey was made in July and August, 1891, and was supplemented by a few days' work in December, 1891, to supply some information which the plotting of the notes showed to be needed. The results of the survey are presented in the charts

* Omitted.

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(5 sheets) accompanying this report. The soundings in the charts are reduced as near as possible to a stage of river corresponding to a stage of Lake Erie 2 feet below the mean level at Buffalo. This stage very nearly corresponds to the lowest stage of the river at Port Day during the past five years. Any lower stage would be of exceedingly rare occurrence. In the adopted project for the improvement of the Niagara River from Lake Erie to Tonawanda the channel is 400 feet wide and 18 feet deep at mean lake level, which is intended to accommodate the largest class of lake vessels.

To continue the channel for vessels of this class from Tonawanda to Port Day, maintaining the 18-foot depth, but with decreased widths, would cost an exceedingly large sum of money, far beyond any amount the expenditure of which would be justified by the possible demands of commerce in the near future. To make such a channel at the least cost, work would be required over a long stretch of river and beyond the limits of this survey, as it is probable that the least expensive method would be to reduce the excavation by raising the water surface inside of a long embankment, extending as far up the river as might be necessary. This is made evident by the calculation of the amount of excavation necessary for a channel inside of an embankment from Port Day to Conners Island, and in open river above, which shows that 1,966,499 cubic yards of solid rock would have to be excavated, which, estimated at $4 per yard, would cost $7,865,996. The inquiry then presents itself as to whether any channel could be made within a reasonable cost of sufficient size to accommodate lake vessels of a smaller class. An examination of the charts shows that for any channel exceeding the depth of 12 feet at mean lake level, or 10 feet at low-water stage, a large amount of rock excavation would be necessary between Tonawanda and the head of Conners Island, in addition to the excavation that will be necessary for any channel below Conners Island. For that depth (12 feet at mean lake level) there is a natural channel, of ample width, for the whole distance from Tonawanda to near Conners Island, except the crossing of a reef about 9,000 feet above Cayuga Island, where the channel would have to be excavated for a distance of about 1,500 feet. As a channel of this depth would permit the passage of a smaller class of lake vessels, an estimate of the cost is presented, which is $1,341,029.80. This is still a very large sum, but a channel with less depth than 12 feet at mean lake level for lake vessels is hardly worth considering.

The proximity of the Erie Canal, connection with which can be made from the Niagara River at Tonawanda, makes it proper, however, to consider smaller channels such as would serve for the passage of canal boats. Estimates are therefore added for a channel of 7 feet depth at low water, which is the depth on the lock sills of the Erie Canal, and for 6 feet depth at low water, which is 8 feet at mean lake level, and which would have a depth of 7 feet for the greater part of the season of navigation. An examination of the charts shows comparatively deep water in the river within about 1,000 feet of Port Day, but it can not be utilized for a channel for navigation, as it is within 1 mile of the falls; and even if it were possible to make a safe channel by inclosing it with a dike, there would still be required a large amount of excavation to make harbor room inside of Grass Island. I therefore deem it imperative to locate the channel inside of the line connecting Conners and Grass islands, where, inside of a dike, vessels would be entirely safe, and the approach to which from the river above would be safe. In all of the plans presented the width of the channel provided for is as follows: In open river, 300 feet; from Conners Island to Grass

Island, 200 feet; from head of Grass Island to Port Day, a gradual enlargement from 200 feet to 400 feet, to allow for harbor room and turning space. In all of the plans provision is made for a loose stone embankment extending from Conners Island to Port Day. This embankment would be made entirely from the rock excavated from the channel, suitable portions of which could be selected and laid so as to make a facing on the slopes. The embankment would serve three purposes: First, it would be a guard to prevent vessels being drawn towards the falls; second, it would raise the water surface in the channel, and more than pay for itself in reducing the amount of excavation; third, it would be a guide for vessels navigating the channel. At the time of the survey the fall of water surface from the head of Conners Island to Port Day was 1.795 feet. It is estimated that with the inclosing embankment this fall would not exceed two-tenths of a foot, as the escape of water would be only that which leaked through the stone embankment and the amount used by mills. The variation in the water level of the river depends, of course, upon the variation of the level of Lake Erie at the head of the river, except in the case of minor oscillations due to wind, which are of short duration.

An examination of the records kept in this office of the readings of Lake Erie water gauge shows the following stages of the water during the periods of navigation from May 1 to December 1 for five years, from 1887 to 1891, inclusive:

Year.	1 to 2 feet above zero.	Zero to 1 foot above.	Zero to 1 foot below.	1 to 2 feet below zero.
	Days.	*Days.*	*Days.*	*Days.*
1887	19	148	44	3
1888	0	71	135	8
1889	1	33	123	57
1890	14	114	86	0
1891	1	2	144	67
Total	35	368	532	135

The zero of the gauge is at the mean lake level.

The level of the lake is below a stage of minus 2 feet so seldom as not to be worth considering. From the above table it will be seen that during the one thousand and seventy days of navigation of the past five years the lake surface was more than 1 foot below zero 12.62 per cent of the total number of days; below zero, 62.34 per cent; at or above zero, 37.66 per cent; more than 1 foot above zero, 3.27 per cent. In a channel 12 feet deep at mean lake level, or 10 feet at a stage of minus 2 feet, there would be 10 feet least depth practically at all times. Eleven feet depth or more for 87.38 per cent of the time; 12 feet depth or more for 37.66 per cent; 13 feet depth or more for 3.27 per cent. The extreme oscillation of the lake surface at Buffalo during the past five years was 10.99 feet, being from 3.2 feet below to 7.79 feet above zero. The extreme oscillation of the Niagara River surface at Port Day during the past six years, was 6 feet, being from 2 feet below mean surface to 4 feet above mean. The highest and lowest stages were caused by storms.

The following is a summary of the estimates of cost of navigable channels of various depths from Tonawanda to Port Day:

For 18 feet depth at mean lake level (if excavated in open river above Conners Island)	$8,694,821.60
For 12 feet depth at mean lake level	1,341,029.80
For 9 feet depth at mean lake level	380,377.80
For 8 feet depth at mean lake level	257,829.00

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With regard to the commercial need for a navigable channel to Port Day, I have to add to what was stated in my preliminary report that the commerce of Niagara Falls has increased about 20 per cent in the past year. I am informed that it is the intention of the company controlling the Hydraulic Canal to double the capacity of the canal, which now furnishes the power for most of the manufacturing establishments at Niagara Falls. The Cataract Construction Company, engaged in the development of an enormous water power, have vigorously pushed the work on one of their tunnels during the past year, and it is now nearing completion. This one tunnel, it is estimated, will furnish one hundred thousand horse power, and negotiations are now pending for the early use of sixty thousand horse power by various manufacturing interests. Work on another tunnel of equal or greater capacity will, it is understood, be commenced in a short time.

The completion of the development of this enormous power, under the control of a company whose stockholders represent an immense amount of capital, can not fail to build up a manufacturing center which will consume large amounts of raw material, such as grain, lumber, ore, etc., that will be largely obtained from the Northwest, whence transportation by vessels on the lakes will be the cheapest method of getting these articles to the mills, and after being manufactured into the various products of the mills their return to the westward by the lakes and transportation eastward by the Erie Canal will be the cheapest way of getting them to their markets.

As stated in my preliminary report, this very large prospective commerce, though seemingly well assured, is in the future; but there is already a considerable commerce, and the assurance of great increase at an early day is very strong.

The only navigation of the river below Tonawanda at present is by a steamboat of light draft (5 feet) running between Buffalo and a landing at the foot of Sugar street, Niagara Falls, opposite Conners Island. The principal business of the steamer is to carry excursionists.

If it should be decided to enter upon the work of improvement of this part of the river I would recommend that a beginning should be made by providing for a navigable channel of the lesser depth, which could be increased as the increase of commerce should demand. A channel 8 feet deep at mean stage is estimated to cost $257,829. According to the experience of the past five years, such a channel would provide a least depth of 6 feet at all times during the season of navigation, a least depth of 7 feet for 87.38 per cent of the time, and a least depth of 8 feet 37.66 per cent of the time. No work would be required above Conners Island. A water route would be opened to Tonawanda and Buffalo, and by connection with the Erie Canal to eastern points, which would be navigable for the largest class of vessels that can use the canal. A channel with a least depth of 12 feet at mean stage, extending as far down the river as Conners Island, could be made at an estimated cost of $149,749.60. Attention is invited to the accompanying letters of Messrs. Albert H. Porter, John J. MacIntire, and Lautz & Long.

I am indebted to Mr. Albert H. Porter, resident engineer, and Mr. George B. Burbank, consulting engineer of the Cataract Construction Company, for information and courtesies extended.

The report of Mr. Ernest Siegesmund, assistant engineer, is appended.

Accompanying this report are the charts* (five sheets) showing results of the survey, with channels laid out upon them; also a printed

* Omitted.

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map* of the town of Niagara, N. Y., showing the hydraulic canal, line of tunnel, and proposed canal of the Niagara Falls Power Company, and the shore line of the river up to and including Cayuga Island, with railroad connections.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. ERNEST SIEGESMUND, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., December 19, 1891.

MAJOR: According to your order dated July 23, 1891, to survey the Niagara River above Port Day to determine a plan for making a safe navigable channel for large vessels from Tonawanda to Port Day, I made preparations at once and started from Buffalo July 24, in the morning, with a steam launch, a rowboat, one recorder, and five laborers. Neither the captain of the steam launch nor I had ever been at Port Day, but as we had to go there with the launch, I laid out a course northerly of Navy Island, near the mouth of Chippewa Creek to Port Day, according to the lake survey of 1875. This course proved the correctness of the map in this vicinity thoroughly. We arrived safely, to the great astonishment of many persons watching our crossing of the river.

Port Day is the name of the inlet of the hydraulic canal, half a mile above the rapids, in the village of Niagara Falls, furnishing water power for several flour mills, barrel factories, paper mills, etc. This canal was planned and commenced by Augustus Porter in 1847. But this was not the first attempt to utilize the water power of the Niagara River. It was made in 1767 by a British officer, De Peyster, who erected a sawmill near the foot of the present mill stream. In 1800, Mr. Stedman erected mills a little below this point.

In 1886, the Cataract Construction Company was incorporated and commenced actual operations October, 1890, to develop 120,000-horse power for manufacturing purposes. This company must be called the instigator of the present movement to improve the Niagara River above Port Day. It is not only the owner of the power, but also of many acres of land along this power, and it has the intention to erect factories as well as sell privileges. It is desirable for these factories to have the raw material of the West brought directly to their doors. To do this the Niagara River needs deepening.

The report of the preliminary examination was made February 28, 1891. It recommended a survey of the river as "worthy of improvement." This recommendation was approved; $500 allowed, and the survey ordered March 11, 1891. The survey commenced July 24, and was finished August 15, 1891. After plotting the field notes of this survey, it was found necessary to cover about 4,000 feet westerly from sheet No. 5, near Gratwick's dock, with soundings in order to get the extent of the ledge running across the river at this point. These soundings were taken December 10 to 13, 1891, and at once plotted. I started at Port Day and surveyed the shore line to above Conners Island, a distance of about 2¼ miles. Triangulations were made to Navy Island, Buckhorn Island, and Grand Island, but I found that the limits of your order were somewhat too far extended to be covered with the amount of money on hand, and with your consent I narrowed it down; that is, I covered all the essential points on the American side and left out the Canada side, Navy Island, Buckhorn Island, and Grand Island.

The survey has been divided in three parts:

No. 1 from Port Day to above Conners Island.

No. 2 above, in front, and below Cayuga Island.

No. 3 below Gratwick's dock.

These points were selected, as an examination of the lake survey map of 1875 showed shoal places in these localities.

After the running of the shore line with the transit, as shown on Sheet No. 2, soundings commenced.

The soundings were taken in the following manner: All the lines from the shore

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* Omitted.

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line into the river were run by the launch or rowboat, according to the depth of the water, on the magnetic meridian line. Where the width the of river did not allow the placing of a flagman on the Canada side or on an island, the rowboat or launch was anchored in the river and the soundings taken from the launch or rowboat. Intersections of the meridian line were taken every fifth sounding with the transit ashore and the intermediate soundings equally divided. Along the shore stations 200 feet apart were measured for starting points, the transit set up, and the place of the flag or the boat determined.

At Cayuga Island and Gratwick's dock the same method was used, and all intermediate points in going and coming sounded over, to determine the correctness of the lake survey map of 1875, and I have to state that the map is correct.

Leaving Buffalo on a calm day, I took the reading of the Buffalo gauge and set gauges at Gratwick's dock and Cayuga Island to the same reading, being two-tenths below mean lake level. At Port Day I found a cast-iron gauge, where water-level observations had been taken by the Cataract Construction Company since 1886; all these gauges were read mornings and evenings during the survey. The readings since 1886 show that the mean stage of the water at Port Day is at the reading of this gauge of 575.246. The lowest water during this period occurred April 6, 1886; gauge reading 573.2. All soundings are reduced to this gauge reading or 2 feet below mean water level. The highest water occurred January 10, 1889; gauge reading 579.2.

The average gauge reading during the survey at Port Day was −0.07 foot below mean stage; at Cayuga Island, −0.2 foot below mean stage; at Gratwick's dock −0.3 foot below mean stage; difference between highest and lowest water during this period 0.4 foot. Two extra gauges were set above and below Schlosser Rapids and a line of levels run from the Port Day gauge to these gauges, to the steamboat landing opposite Conners Island, at the foot of Sugar street, and to the head of Conners Island, giving a rise of water surface of 1.795 feet between Port Day and the head of Conners Island.

Borings were made around the islands and along the shore, where an accumulation of mud and sand had taken place.

On all important points current measurements were made with a current meter kindly loaned by Albert H. Porter, resident engineer of the Cataract Construction Company, at Niagara Falls.

The bottom of the first section is all bare rock; only around the islands and along the main shore is a small accumulation of mud, sand, etc. Piles driven for the steamboat landing at the foot of Sugar street went through 4 feet of mud.

The second section at Cayuga Island is also rock bottom, here and there with a thin covering of sand or mud in the indentations of the rock surface and mud accumulation along the island. Piles driven for a dock went through 6 feet of mud.

The third section at Gratwick's dock is rock in the center of the river. Along the main shore and Grand Island is some sand and mud. After plotting the field notes you determined to submit four projects for the improvement by giving—

1. A channel, with embankment for vessels of all sizes now navigating the lakes, 16 feet deep at low water. The estimate is based on rock excavation in the open river for the whole length.
2. A channel with embankment 10 feet deep at low-water mark.
3. A channel with embankment 7 feet deep at low-water mark.
4. A channel with embankment 6 feet deep at low-water mark.

This low-water mark is 2 feet below mean stage of the river; so these projects respectively call for 18 feet, 12 feet, 9 feet, and 8 feet at the mean stage of the water. The first project would give a continuous channel of 18 feet depth from Lake Erie to Port Day, as the project for improving the Niagara River from Lake Erie to Tonawanda, giving an 18-foot channel, is already approved and under construction. The channel on Sheet No. 2, or from Port Day to above Conners Island, is 200 feet wide; above Conners Island to Tonawanda it is intended to make it 300 feet wide in the open river. The line of the channel for all projects on Sheet No. 2 is as follows: It commences about 1,800 feet easterly of Conners Island, 200 feet wide; at the head of this island and between the island and the main shore it widens, taking in all the deep water in this vicinity to a point about two-thirds of the length of the island. From here it is again 200 feet wide and runs in an easy curve with a radius of 10,000 feet to avoid the cutting of a rocky bar for the whole depth of the channel to Grass Island, for a length of about 6,000 feet; thence, with a light curvature to the south and farther, on a tangent to this curve to a point about 790 feet in the prolongation of the westerly dock line of Port Day; thence to the present westerly corner of this dock. The inner line of the channel from Grass Island to Port Day gradually widens, in order to make a harbor there and allow vessels to turn. The excavation along the whole line is through solid rock. This excavated rock will be used to build an embankment to protect the channel and make it safe. It is intended to face this embankment on both sides with stones laid so as to form a rough slope wall from 1

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foot below low water. The embankment will be 6 feet wide on top with slopes 1:1½, and 4 feet above mean, the highest water known according to gauge readings at Port Day since 1886. The center line of this embankment is intended to be 50 feet from the southerly line of the channel, and is 9,000 feet long.

The embankment will inclose the area from Conners Island to Grass Island and to Port Day; this will raise the water at Port Day about 1.59 feet, allowing 0.2 fall for leakage through the embankment.

Sheet No. 3 shows no excavation is needed near Cayuga Island for a 6-foot, 7-foot, or 10-foot channel; the 16-foot channel requires excavation for a length of about 4,400 feet.

Sheet No. 4 shows no excavation is necessary for a 6-foot, 7-foot, or 10-foot channel; about 3,600 feet in length must be excavated for 16-foot channel.

Sheet No. 5 shows no excavation necessary for a 6-foot or 7-foot channel; for a 10-foot channel a cutting through a ledge across the river for a length of about 1,500 feet is necessary; for 16-foot channel a length of about 10,000 feet must be excavated.

ESTIMATED COST.

Project No. 1.

For a channel 16 feet deep at low water or 18 feet at mean-water level, 300 feet wide in open river and 200 feet wide below Conners Island, with embankment to Port Day:

Rock excavation, 1,966,499 cubic yards in place, at $4 per cubic yard	$7,865,996.00
Embankment: Placing 83,300 cubic yards of loose rock in line of embankment, at 25 cents per cubic yard	20,825.00
Facing with selected stones laid by hand, 23,420 square yards, at 75 cents per square yard	17,565.00
	7,904,386.00
Contingencies, 10 per cent	790,458.60
Total	8,694,824.60

Project No. 2.

For a channel 10 feet deep at low water or 12 feet at mean water level, 300 feet wide in open river and 200 feet wide below Conners Island, with embankment to Port Day:

Rock excavation, 295,182 cubic yards in place, at $4 per cubic yard	$1,180,728.00
Embankment: Placing 83,300 cubic yards of loose rock in line of embankment, at 25 cents per cubic yard	20,825.00
Facing with selected stones laid by hand, 23,420 square yards, at 75 cents per square yard	17,565.00
	1,219,118.00
Contingencies, 10 per cent	121,911.80
Total	1,341,029.80

Project No. 3.

For a channel 7 feet deep at low water or 9 feet at mean water level, 200 feet wide, with embankment from Conners Island to Port Day:

Rock excavation, 76,852 cubic yards in place, at $4 per cubic yard	$307,408.00
Embankment: Placing 83,300 cubic yards of loose rock in line of embankment, at 25 cents per cubic yard	20,825.00
Facing with selected stones laid by hand, 23,420 square yards, at 75 cents per square yard	17,565.00
	345,798.00
Contingencies, 10 per cent	34,579.80
Total	380,377.80

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Project No. 4.

For a channel 6 feet deep at low water or 8 feet at mean water level, 200 feet wide, with embankment from Conners Island to Port Day:

Rock excavation, 49,000 cubic yards in place, at $4 per cubic yard	$196,000
Embankment: Placing 83,300 cubic yards of loose rock in line of embankment, at 25 cents per cubic yard	20,825
Facing with selected stones laid by hand, 23,420 square yards, at 75 cents per square yard	17,565
	234,390
Contingencies, 10 per cent	23,439
Total	257,829

Finally, please allow me two remarks: Would it not be most economical and advantageous to the Government, if any of the projects for improvement of the Niagara River above Port Day is approved and adopted, to let the whole work in one contract and not divide it into small contracts according to the appropriations made? It requires a special plant adapted for this locality. None of the drill boats, dredges, or scows at the present time on the lakes could do the work on account of lack of water.

If any one of the projects is adopted, would it not be well to connect the Buffalo gauge with the Port Day gauge by a line of levels, establish bench marks, and set water gauges on all points where improvements are contemplated, in order to get more definite data than at present on hand? The mean lake level is known; the mean stage of the water at Port Day is also known. What is needed is to establish the mean stage of the water on all necessary points along the river, a distance of about 23 miles.

Annexed please find a letter from Mr. MacIntire, vice-president of the Business Men's Association at Niagara Falls, giving statistics of the place from January 1 to November 1, 1891.

A letter from A. H. Porter, resident engineer of the Cataract Construction Company, giving details of the work done during the same period.

A letter from Messrs. F. C. M. Lautz and Long, proprietors of Cayuga Island, setting forth their intentions.

Very respectfully, your obedient servant,

ERNEST SIEGESMUND,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

LETTER OF MR. JOHN J. MACINTIRE.

NIAGARA FALLS, N. Y., *November 4, 1891.*

MY DEAR SIR: In reply to your inquiry of this date regarding the amount of business done by the different industries at this place, I beg to hand you the inclosed statement. The figures given are as near the actual figures as can be given without going over the records of the different firms. I take pleasure in calling your attention to the rapid increase in the volume and value of the output of our mills and factories during the past year.

The best indication of the rapid growth here is the increase in the freight traffic by the railroads here, said increase being 20 per cent during the past year.

I trust the information given will be such as you require.

Very truly yours,

JOHN J. MACINTIRE.

E. SIEGESMUND, Esq.

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Amount and value of output of the mills and factories at Niagara Falls, N. Y., January 1 to November 1, 1891.

Industries.	Output.	Value.	No. of employés.	Wages.
3 flour mills	954,000 barrels	$5,247,000	120	$54,000
4 paper mills	12,000 tons	675,000	148	52,500
3 pulp mills	5,400 tons	129,600	42	17,260
3 cooper works	568,000 barrels	189,450	136	51,400
1 brewing company	36,000 barrels	252,000	43	22,680
1 silver plate and chain works		209,000	228	56,200
1 blank book manufactory		343,000	176	41,750
6 building firms		293,000	178	112,160
1 light and power company		20,000	8	5,000
2 machine works		38,000	28	17,320
1 box works	178,000 boxes	11,000	36	3,900
Total		7,407,050	1,143	434,170

The freight business now averages per day, 70 car loads in; 45 car loads out.

Lease has been signed and recorded at the county clerk's office between the Soo Paper Company of Chicago and the Niagara Falls Power Company for 3,000 horse power for forty-five years at $24,000 a year. The first quarterly payment of this annual rent has to be made December 1,1892. The Soo Paper Company's mills will be, so it is said, the largest establishment, both wood pulp and paper, in the United States, perhaps the world. They will be built principally on made land, between Tenth, Buffalo, the southern extension of Bademan street and the Niagara River, and will cover from 11 to 12 acres. Their output is expected to be more than the combined output of the present four paper and three pulp mills.

LETTER OF MR. ALBERT H. PORTER, ENGINEER, CATARACT CONSTRUCTION COMPANY.

NIAGARA FALLS, N. Y., *November 14, 1891.*

DEAR SIR: Your letter of October 31 in reference to notes of progress on the tunnel work for the report of your office is received.

The present contract includes the construction of a tunnel and open cut 6,700 feet long, the soffit of which lies at an average depth of 170 feet beneath the surface, the grade being seven-tenths per cent.

The cross section is to be 335.5 square feet, and of uniform area; excavation to be lined when necessary with permanent timbering in five block timber arches with lagging, and tunnel to be lined throughout with four rows of brick.

Work was commenced on October 4, 1890. On November 1, 1891, 3,437 feet of heading had been driven, and 2,938 feet of bench had been taken out, 3,093 feet of heading remaining yet to be excavated.

Of the 3,437 feet of heading driven, 2,877 feet was permanently timbered, 394 feet driven for masonry section.

The headings and first bench are to be taken out until headings meet, when the second bench is to be excavated to the required depth, and the masonry put in as rapidly as the preparation of the excavation admits.

Large quantities of brick and other material are already on the ground.

The greater part of the tunnel thus far constructed lies in gray slate and shale, necessitating temporary timber support in headings for the safety of the men, and requiring that the permanent timbering be kept up within a short distance of the faces.

About 780 feet from the east bank of the lower river a stratum of Queenston limestone was encountered which forms a substantial roof, no permanent timber being required. At this point rapid progress was made, 78 feet of heading being driven during one week of thirteen shifts.

The company is at present excavating the first section of their canal, and filling in embankments on the lands under water, forming the same. The earth is loosened by blasting and thrown into scale boxes, which are raised from the pits by traveling derricks mounted to run along the banks. These boxes are placed on trucks directly from the derricks and rapidly hauled to the point of fill. Excellent rock for the side walls is being taken from the excavation, steam drills being used on the ledge. Both centrifugal and cylinder pumps are used in keeping excavation clear of water.

Yours very truly,

ALBERT H. PORTER,
Engineer.

Mr. ERNEST SIEGESMUND,
Assistant Engineer.

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LETTER OF MESSRS. FRED. C. M. LAUTZ AND BENJAMIN G. LONG.

BUFFALO, N. Y., *July 31, 1891.*

DEAR SIR: The undersigned, owners of Cayuga Island, desire to call your attention to the fact that we have purchased and commenced to improve the aforesaid island to the end that it may be utilized for commercial purposes. Cayuga Island, containing 140 acres, has a river frontage of 6,800 feet which can be utilized for dockage if a navigable channel connecting with Lake Erie is brought contiguous to it.

You are undoubtedly aware of the fact that the river front in and about Tonawanda has already been taken up with docks and mill sites, and that a move farther down the river for commercial purposes, especially in view of the tunnel developments at Niagara Falls, is inevitable.

A careful consideration will convince any one that Cayuga Island is the next most available river frontage down the river. With the foregoing in view, a terminal railroad company has been organized, who have laid out and secured the right of way for a railroad upon and around the island to connect with the New York Central and Erie railroads upon the main land, so that so soon as a proper channel shall be made to or near the island mills may be erected and lumber yards established which will be in reach of the cheap power from the falls tunnel, and be contiguous to lake and river navigation, and also have railroad facilities unsurpassed elsewhere in the country.

Our object in securing this property is to so improve it that the foregoing commercial undertakings may be properly equipped in every way for economical business purposes.

Respectfully submitted,

FRED. C. M. LAUTZ.
BENJAMIN G. LONG.

MR. ERNEST SIEGESMUND,
U. S. Assistant Engineer.

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APPENDIX O O.

IMPROVEMENT OF HARBORS ON LAKE ONTARIO EAST OF OAK ORCHARD, NEW YORK.

REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Harbor at Charlotte, New York.
2. Harbor at Pultneyville, New York.
3. Harbor at Great Sodus Bay, New York.
4. Harbor at Little Sodus Bay, New York.
5. Harbor at Oswego, New York.
6. Harbor at Sacketts Harbor, New York.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., July 9, 1892.

GENERAL: I have the honor to transmit herewith annual reports for the fiscal year ending June 30, 1892, for the following works under my charge.

* * * * * * *

I have the honor to be, very respectfully, your obedient servant,
DAN C. KINGMAN,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

O O 1.

IMPROVEMENT OF HARBOR AT CHARLOTTE, NEW YORK.

OBJECT.

To secure a navigable channel at the mouth of the Genesee River on Lake Ontario.

Charlotte Harbor is the port of the city of Rochester, which is situated 2 miles above the head of the navigable part of the river forming the harbor.

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PROJECT.

1829.—To obtain a channel 480 feet wide and 12 feet deep, formed and protected by parallel piers extending to deep water of the lake; executed in 1834.

1881.—To secure and maintain by pier extension and dredging a channel of navigable width and 15 feet depth at extreme low water. No dredging had heretofore been done, the channel having been formed and kept open with 12 feet depth by the current of the Genesee River.

PRESENT WORKS.

The piers which define and maintain the channel are formed of cribs of timber, 20 feet wide and 30 feet long, sunk, end to end, in as close contact as practicable, by filling with loose stone. The cribs forming the original work were built of round logs hewed flat, and were allowed to settle into the natural sand bottom upon which they were placed, each crib having two to four oak guide piles driven on each side of it to keep the crib in line while settling into the sand. A continuous timber superstructure was then built upon the cribs for the full width of 20 feet, and for 3 to 5 feet in height above the mean lake level. The whole was then filled with loose stone and decked with 3-inch pine plank. The cribs being below water, and not subject to decay, were built of hemlock timber, fastened together with tie-heads and drift-bolts, while the continuous superstructure was built of white pine timber and plank similarly fastened. The latter has a life of about 15 years.

(1) *West pier.*—This has a total length of 3,257 feet, in addition to a shore-return of 137 feet.

The width was originally 20 feet throughout, but the accretion against the west side of the west pier has advanced the lake shore line 1,200 feet, and the inner 900 feet was last renewed 10 feet wide.

Section A, from the shoulder-angle of the return, at the shore line of 1829, for 554 feet northward toward the lake. The cribs forming its superstructure were built in 1829–1834 of flatted logs, and are still sound. The superstructure was first rebuilt in 1853, was again rebuilt in 1864–1868, and was last rebuilt in 1869, with a width of 10 feet. It is now decayed to mean water level (2.4 feet above extreme low water) and its renewal has not since been necessary.

Section B, 564 feet northward from last section. The cribs were built in 1829–1834, and are still sound. Superstructure was first rebuilt in 1853, was again rebuilt in 1864–1868, and was last rebuilt with oak timber in 1885, part 10 feet and part 20 feet wide, by the Ontario Beach Improvement Company, forming, with Section A, the water front of the accretion since 1829, which is now owned by the New York Central and Hudson River Railroad Company, and is leased and occupied by the Ontario Beach Improvement Company as a summer resort.

The following sections extend out into the lake to 14 feet depth at extreme low water:

Section C, 1,402 feet long, 20 feet wide. The cribs were built in 1829–1834, and are still sound. The superstructure first rebuilt in 1853, was again rebuilt in 1864–1868, and was last rebuilt in 1887–'88, 20 feet wide and 4 feet above mean water.

Section D, 235 feet long, 20 feet wide. The cribs were built in 1829–1834, and are still sound. The superstructure was first rebuilt in 1853; was again rebuilt in 1864–1868, and was last rebuilt in 1891.

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Section E, 303 feet in length; cribs 30 feet long, 20 feet wide, built of sawed 10-inch by 12-inch hemlock timber, with tight floors placed upon the natural sand bottom in about 12 feet of water. Superstructure of 10-inch by 12-inch white pine, 20 feet wide, was bonded back 11 feet into the preceding section; cribs and superstructure were built in 1883.

Section F, 201 feet in length (including timber horns projecting at the outer end), formed of cribs 50 feet long, 20 feet wide, built of sawed 10-inch by 12-inch hemlock timber, the floor being built in center only, and omitted for width of 4 feet along each side. Sunk in 13 feet depth upon a riprap foundation, about 4 feet in thickness and 30 feet wide, deposited upon the natural sand bottom. These cribs differed from previously built cribs at this harbor in being 50 feet long instead of 30 feet; in having a riprap foundation; in having a partly open bottom (which feature has given unsatisfactory results as compared with those having tight bottoms). They also differ in having, besides the usual drift-bolt fastenings, six vertical pine posts in each crib extending from the grillage bottom to the top of the superstructure, and screw-bolted to each timber; and they have a tight deck laid longitudinally directly upon the top set of cross-ties. Cribs and superstructure were built in 1885.

(2) *East pier.*—This has a total length of 2,896 feet, in addition to an abandoned shore connection 402 feet in length, upon which the superstructure has not been renewed since its original construction in 1829–1834, and which is now destroyed to nearly the level of the surrounding bottom, only its guide piles showing above low water. The width was originally 20 feet throughout, the substructure being of separate cribs and the superstructure of continuous timber work, similiar in detail to the west pier structures before described.

Section A, 325 feet in length, measuring toward the lake from a large leaning oak pile at the south end of the work now visible; cribs 30 feet long and 20 feet wide, built 1829–1833, and still sound below mean lake level. Superstructure, 20 feet wide, decayed to mean lake level, having been first renewed in 1864–1867 and not since then. The stone filling of the superstructure was taken in 1887 to refill exposed portions of the pier; this portion being within the shore line.

Section B, 100 feet in length; cribs are the same as last section, and had tops sunk upon them in 1868–1870. Superstructure was first renewed in 1868–1870, received general repairs in 1880, and was last renewed for 4 feet above mean lake level in 1887 by the United States Life-Saving Service of whose station it forms the water front. The sections following are in the open lake:

Section C, 225 feet in length; cribs are the same as last section, and had tops sunk upon them in 1868–1870; superstructure was first rebuilt in 1868–1870, received general repairs in 1880, and was last renewed in 1889.

Section D, 797 feet in length; cribs are the same as last section and had tops sunk upon them in 1868–1870; superstructure was first rebuilt in 1868–1870; received general repairs in 1880 and was last rebuilt in 1886–'87.

Section E, 995½ feet in length; cribs are the same as last section; were built in 1833-1834 and had tops sunk upon them in 1868-1870. The superstructure was first rebuilt in 1868-1870; 750 feet of it was again built in 1881-1882, and the whole was last rebuilt in 1890.

Section F, 303 feet in length; cribs 30 feet long 20 feet wide, built of sawed 10-inch by 12-inch hemlock timber with tight floors placed upon the natural sand bottom in about 12 feet of water. Superstructure of

10-inch by 12-inch white pine, 20 feet wide, bonded into preceding section. Cribs and superstructure were built in 1883.

Section G, 150½ feet in length; formed of cribs 50 feet long and 20 feet wide, built in the same manner and with the same details as the cribs forming the last section of the west pier. Cribs and superstructure built in 1884-1885.

CHANNEL.

The channel between the jetties is now in good condition, having 15 feet depth at extreme low water with 1 foot less in the lake outside the jetty ends.

The channel was formed and maintained with a depth of about 12 feet at the extreme low water by the scouring action of the river current alone from the time of building the jetties in 1829. In 1888 the low stage of water in the lake and the increased size of vessels to 14 feet draft combined to require a greater depth in the channel, and the first dredging at this harbor was then done, taking 4,656 cubic yards of sand and 26 buried logs and trees from the shoalest part of the entrance. This temporary relief was followed in 1889 and 1890 by the complete dredging of the eastern half of the channel between the jetties for 200 feet in width and 2,700 feet in length to a depth of 16 feet at extreme low water; 113,871 cubic yards were dredged at 16.9 cents in scows.

In 1891 the improvement of the channel was continued by a similar dredging of the western half of the channel between the jetties. One hundred and two thousand one hundred and ninety-three cubic yards of sand and gravel were then removed during 1891, of which total 83,513 cubic yards were dredged during this fiscal year, at 12 cents per cubic yard, scow measurement. This completes the channel 380 feet wide and 2,700 feet long between the jetties, except a portion along the west side at the inner end, 1,100 feet long and 70 feet average width, containing about 20,000 cubic yards of sand.

To deepen the entrance to 18 feet in the lake outside the jetty ends will require an average cut of 2 feet for a length of about 600 feet, involving the removal of about 20,000 cubic yards of sand. Such a cut will soon refill unless the jetties are extended to shelter it.

OPERATIONS.

Dredging was in progress at the beginning of the fiscal year under written contract with J. & T. Conlon. The contractors continued the work until October 31, 1891, at which time they had removed 90,798½ cubic yards of material under their contract, or 73,118½ cubic yards during the fiscal year. They then asked for and were granted an extension of time to enable them to complete the 100,000 cubic yards called for in their contract. This was accomplished on the 13th of November. The contractors were required to pay the cost of inspection during this period; the amount, $43.33, was deducted from their final payment. They were then kept at work four days longer at the contract rate, during which time they dredged 2,193½ cubic yards.

The total amount of material removed during the year was therefore 83,513½ cubic yards. The cost was as follows:

For dredging	$9,758.40
For inspection	466.67
Total	10,225.07

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The work of renewing the superstructure by hired labor, on section D, 235 feet of the west jetty was begun on August 11, 1891, and completed November 19, 1891. In addition to this work, the same party repaired two small breaks in the jetties, and also repaired injuries to them resulting from their being run into by the barges *Wheeler* and *Hiawatha*.

The party also finished up certain work on section E of the east jetties, that could not be completed last year. In rebuilding Section D, the party was obliged to take down and put up again a corresponding portion of the elevated walk leading to the light-house.

The amounts for these several objects was as follows:

Repair of two small breaks—	
Labor	$40.92
Material	13.87
Total	54.79
Repair of damage to piers by vessels	$144.90

This last sum was collected from the parties in fault by the United States attorney for the northern district of New York, without a suit, and has been taken up and accounted for.

Finishing Section E, east jetty—	
Labor	$217.38
Material	18.91
Total	236.29
Extra cost on account of elevated walk	$170.47

For renewal of superstructure on Section D, west jetty, there was expended for labor and new material, $2,179.43, divided as follows:

Labor	$1,182.37
Lumber (new)	804.43
Iron	122.12
Tools and materials	70.51
Total	2,179.43

There was also expended for reading water gauge during the portion of the season when there were no employés available for this work, $63.34.

By authority of the Chief of Engineers $8,000 was expended from this appropriation towards the purchase of a dredging plant. The total amount expended for all purposes, including engineering and office expenses and inspection to the work during the year was $23,291.35.

REMARKS.

Surveys made this season after the spring freshets show that no bar has formed beyond the end of the jetties. My assistant engineer who made the surveys suggests "that this bar may have been formed in the past from material washed from the channel between the jetties, and that this supply of material has been annually renewed by the sand washed through the jetties (which are not sand-tight) and by sand blown into the channel from the adjacent beaches. The enormous advance of the shore-line (some 1,200 feet since the jetties were built) proves that there has been plenty of material in motion to keep up the supply in the channel. The Ontario Beach Improvement Company has of late reclaimed this sand bar by covering it with soil and sod out to the water line; so that this material is now held in place. The recent dredging has increased the channel capacity between the jetties some 20 per cent, so that the current can now have but little tendency

to scour it. If this is so, then there is reason to hope that the bar will not form again. This theory is ingenious, but it can only be demonstrated by a series of sediment observations taken during high water in the river, at the upper and lower ends of the jettied channel, and by comparative surveys of the channel during the same period. I am of the opinion that the river itself brings down a good deal of silt, and that a portion of it may now be deposited in the channel, reducing its depth so that it may ultimately require redredging.

As stated elsewhere, the channel between the jetties has a general depth of 15 feet at extreme low water; but the jetties terminate near the 13-foot contour, and therefore the full depth of the improved channel is not available. I doubt if a dredged channel would maintain itself beyond the end of the jetties. I can find no record that it has ever been tried. But I have so little confidence in it that I would recommend that the approved project of extending the jetties to the 15-foot contour be carried out as rapidly as the means provided will allow.

Name of harbor, Charlotte, N. Y.; collection district, Genesee, N. Y. (at Charlotte). A fixed red light of the fourth order on crib 300 feet inside of outer end of west pier. A range light of 3 fixed lights, 2 red and 1 white, 60 feet high, at inner end of west pier. Forts Niagara and Ontario, N. Y., are the nearest works of defense.

Money statement.

July 1, 1891, balance unexpended	$34,699.85
February 26, 1892, received from vessels for damages to piers	144.90
Total to be accounted for	34,844.75
June 30, 1892, amount expended during fiscal year	23,291.35
July 1, 1892, balance unexpended	11,553.40
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	36,553.40
Amount (estimated) required for completion of existing project	109,650.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	75,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Charlotte Harbor, New York, during fiscal year ending June 30, 1892.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home, on lake	371	48,784	65	8,698	211	71,253
Foreign, on lake	242	113,521	295	55,239	153	58,868
Total	613	162,305	360	63,937	364	130,121
American owned	377	54,906	46	4,869	285	98,161
Canadian owned	236	107,399	314	59,068	79	31,960

Sum total, 1,337 arrivals; 356,353 registered tons.

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Arrivals and departures of vessels at Charlotte Harbor, etc.—Continued.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home, on lake	376	54,975	40	4,644	204	67,720
Foreign, on lake	236	106,969	317	59,229	160	62,401
Total	612	161,944	357	63,873	364	130,121

Sum total, 1,333 departures; 355,938 registered tons.

Greatest draft of vessels, 14 feet.
Greatest tonnage of vessels, 1,583 registered tons.
Greatest load of vessel, 2,130 net tons of coal.

Receipts and shipments by lake at Charlotte Harbor, New York, during fiscal year ending June 30, 1892.

RECEIPTS.

Trade.	Passengers.	Grain.	Merchandise.	Live animals.	Poles and ties.	Post and wood.	Lumber, etc.
	No.	*Net tons.*	*Net tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Home, on lake	22,108	.....	44	.....	.....	.....	.....
Foreign, on lake	9,222	6,385	329	683	2,282	3,668	4,425
Total	31,330	6,385	373	683	2,282	3,668	4,425

SHIPMENTS.

Trade.	Passengers.	Merchandise.	Oil.	Coal.
	No.	*Net tons.*	*Tons.*	*Net tons.*
Home, on lake	22,359	59	.....	186,162
Foreign, on lake	8,540	375	73	275,922
Total	30,809	434	73	462,084

Navigation closed December 20, 1891.
Navigation opened March 29, 1892.
Total revenue collected at port during the fiscal year, $98,858.50.
For the purpose of reduction to tons weight, the following is assumed: Barrels oil, 7 equal 1 ton; M lumber, 1 equal 1½ tons; crates fruit, 20 equal 1 ton; railroad ties and poles, 12 equal 1 ton; cords wood and posts, 1 equal 1½ tons; live animals, 4 equal 1 ton.

O O 2.

IMPROVEMENT OF HARBOR AT PULTNEYVILLE, NEW YORK.

OBJECT.

To furnish a protected channel of navigable width and not less than 10 feet depth at the mouth of Salmon Creek, Wayne County, N. Y., which is situated 21 miles east of the Genesee River.

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PROJECT.

The present project of 1872 provides for a breakwater running 330 feet eastward from the west side of the creek, a west pier or jetty thence northward into the lake, and an east pier or jetty about 200 feet eastward from the west pier and parallel to it.

Also a dredged channel between the piers and behind the breakwater, and extending about 400 feet up the creek.

After this work was done, at a total expenditure of $71,000, it was found that the waves from the lake when driven by a gale from the northwest would strike the east pier in such a way as to be reflected upon the beach within the harbor, and that in receding they would sweep the gravel and sand from the beach into the excavated channel along the harbor side of the breakwater, where it would lodge across the mouth of the creek.

Accordingly it was further proposed in 1884, in order to make dredging of permanent value and effect, to build a sand-tight structure 500 feet in total length, parallel to the breakwater and about 100 feet from it, between it and the harbor beach, so as to arrest this movement of material.

A part of this structure has been built during this fiscal year.

PRESENT WORKS.

(*1*) *West breakwater.*—This has a total length of 330 feet, and is formed as follows:

Section A, from the west shore line eastward, 150 feet in length and 15 feet in width, formed by cribs of flatted round logs built at local expense before the General Government undertook the improvement of the harbor in 1867, $30,000 having been thus expended before that year.

The superstructure, 15 feet wide and 4 feet above mean lake level, was repaired by the United States in 1871, was rebuilt in 1877, and is still in place in a half-ruined condition. The gravel from the lake beach has washed over it, and has aided in closing the entrance to the creek.

Section B, from section A to the west pier which it joins, is 180 feet in length, 20 feet in width, formed of tight-bottomed cribs, each 30 feet long, 20 feet wide, and 9½ feet deep. These cribs were built by the United States in 1871 of sawed 12 by 12 inch hemlock timber and were sunk, in close contact, in a trench dredged to the depth of the proposed channel about 8 feet below extreme low-water level. The cribs were filled with loose stone gathered from the neighboring shore of the lake. The continuous superstructure which was built by the United States upon these cribs in 1871 was formed of sawed pine timber framed together, bolted with drift bolts, and ballasted with loose stone from the lake shore.

It has not since been renewed, and is decayed, though still in position. The substructure of this and the preceding section is sound up to mean level, 2.4 feet above extreme low water.

(*2*) *West pier.*—This has a total length of 558½ feet and is 20 feet wide. Its substructure is formed of separate cribs sunk in close contact and its superstructure is continuous, except on section D, which is separate.

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Section A is 222 feet long, from the shoulder angle northward. It is formed of eight separate cribs, one irregular angle crib, measuring 12 feet on its face, and seven regular cribs, each 30 feet long and 20 feet wide, and 7 feet deep.

The cribs were built in 1874–1875 of sawed hemlock timber 12 inches square, had tight floors upon screw-bolted grillages, and were sunk, in 1874–1875, in a foundation trench dredged to 8 feet depth at extreme low water where the natural depth was 4 feet. The cribs are still sound.

The superstruction was built upon them in 1874–1875 of 12-inch square pine timber, 4 feet high, filled with loose stone and decked with 3-inch pine plank laid crosswise, with 2-inch spaces. This has not since been renewed, and is decayed, but still in position.

Section B is 93½ feet long, from last section northward. It is formed of 3 separate cribs, each 30 feet long, 20 feet wide, and about 9 feet deep. They were built in 1880 like those of the last section, with similar superstructure, and sunk in a trench dredged to 8 feet depth.

The cribs are still sound, but the superstructure needs repair.

Section C is 183 feet long, from last section northward. It is formed of six separate cribs, each 30 feet long, 20 feet wide, and about 9 feet deep. They were built in 1881 like those of the last section, except that the foundation trench was not dredged for all the cribs, its completion being prevented by encountering a mass of large bowlders embedded in clay, which the dredge could not remove.

One of the cribs rested partly upon these bowlders and partly upon the riprap, and others rested partly upon the sand among the bowlders, and about 100 feet afterwards settled irregularly.

The superstructure was built upon the cribs in the same season, 1881, and has not since been repaired, except that in 1884 it was leveled for 98 linear feet by raising the east wall 2 to 3 feet and relaying the deck. Fifty feet of this again needs similar leveling, refilling, and redecking.

Section D is 60 feet long from the last section northward, and forms the outer end of the pier.

It is formed of two cribs similar to those built in 1874–1875 and since, each 30 feet long and 20 feet wide and 12 feet deep. The cribs were built 1883, of sawed hemlock timber, 10-inches by 12-inches square (the two upper courses being of white pine), with tight floors upon screw-bolted grillages, and they were sunk upon a bed of riprap 3 feet deep and 40 feet wide, where the natural depth was about 10 feet at extreme low water.

The superstructure was built upon them 4 feet high in 1883. The cribs have not settled at all, and now stand level, 2 feet above the adjoining irregular work.

The outer end of the pier was breached at some time prior to 1890, the stone filling was washed out to 9 feet depth, from the outer half of the outer crib, and the entire end wall is now gone, the deck and superstructure remaining.

It is fully exposed, and will be destroyed unless the end is rebuilt.

(3) *East pier.*—This has a total length of 571½ feet, with a varying width of 15 to 20 feet as described below. It was all built between 1872 and 1880, and was formed of cribs, each 30 feet in length, 15 to 20 feet in width, and generally 6 to 8 feet in depth.

The cribs were built of sawed hemlock timber, 12 inches square, had tight floors upon screw-bolted grillages, and were sunk on the natural bottom in depths of 6 to 8 feet at extreme low water. The superstructure

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was built upon the cribs during the same year, of 12-inch square pine timber, 4 feet high, filled, as were the cribs, with loose stone, and decked with 3-inch pine plank laid crosswise with 2-inch spaces.

The different sections were built, first at one end of the jetty and then at the other end, as seemed most useful.

Section A, beginning 140 feet from the present shore line (at the end of a private wharf, since destroyed), extending 85½ feet northward into the lake, 16 feet wide. It was formed of three cribs, two 30 feet long, and one 25½ feet long. They were sunk upon the remains of a wrecked private wharf, leveled to receive them. Its superstructure, also 16 feet wide, was 4 feet high. Both were built in 1880 and are still in fair condition.

Section B, 62 feet in length, 15 feet in width, built in 1877, and not since renewed.

Section C, 30 feet in length, 20 feet in width, built in 1877, and not since renewed.

Section D, 92 feet in length, 20 feet in width, built in 1873, and not since renewed.

Section E, 180 feet in length, 120 feet in width, built in 1872, and not since renewed.

Section F, 122 feet in length, 20 feet in width, built in 1873, and not since renewed.

In all these sections the cribs are sound, but the superstructure needs renewal, without which the whole will be wrecked.

(4) *Sheet-piling.*—Of the constructure to arrest sand drift from the harbor beach to the channel into the creek, which was proposed in 1884, 200 linear feet, from the east side of the creek outlet eastward toward the land end of the east jetty have been built during the fiscal year. The work was done by hired labor, at a total cost of $1,555.85, equal to $7.78 per linear foot complete.

The structure is sand-tight, being formed of the Wakefield patent sheet-piling. Its oak wale-pieces are below the line of no decay, and they are tied back by iron rods to logs buried in the bottom, upon which the accretion will probably form, so that the structure may be expected to be a permanent one. It has already produced an effect in causing a scour of the shoal between it and the breakwater, but dredging will be needed to make a navigable channel.

CHANNEL.

The channel between the jetties, behind the breakwater and 400 feet up the creek, had been dredged in former years to 8 to 9 feet depth at extreme low water; but it has since shoaled to 7 feet between the jetties and 2 feet at the creek outlet. The dredging which has been done is as follows:

In 1874, 14,189 cubic yards of sand and gravel were removed at 32½ cents per cubic yard, making an effective depth of 8 feet at extreme low water, 25 to 40 feet wide and 600 feet long between the jetties, and 10 feet depth for 50 feet width, and 400 feet length behind the west breakwater to the creek outlet, and 40 feet width for 400 feet up the creek.

This dredging made known the existence, in the space between the jetties, of a deposit of bowlders embedded in stiff clay and cemented gravel, which was most difficult to remove, none of which was taken

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out until the next year (1875) when a special contract was made for its removal. Under this contract, in 1875, 7,700 cubic yards of hard material was excavated between the jetties at 70 cents per cubic yard, and 2,173 yards of sand and mud was excavated from the creek channel at 20 cents per cubic yard. This gave an entrance 130 feet wide and 9 feet deep at extreme low water.

In October, 1879, the space between the jetties (then 222 feet long) had 7 and 8 feet depth at extreme low water, but the cut behind the breakwater and up to the creek outlet had filled with sand from the harbor beach, so that there was only 2½ to 4 feet depth at extreme low water for 30 feet width. In 1880 the entrance was dredged to 8 feet depth at extreme low water for 150 feet eastward from the west jetty, and for 250 feet northward from its junction with the west breakwater. Behind the breakwater the same depth was made for a width from the breakwater of 70 feet at the shoulder angle, narrowing to 50 feet at the creek outlet, and thence for 50 feet width up the creek. In this year there was removed 20,450 cubic yards of sand, gravel, and mud at 18 cents per cubic yard, and 806 cubic yards of bowlders and hard material at $1 per cubic yard.

Since 1880 no more dredging has been done. Meantime the west jetty has been extended 336 feet further into the lake, so that the entrance is better sheltered from sand drift, and 7 to 8 feet depth continues in it.

The space behind the breakwater has again filled with sand from the harbor beach, but this movement will be arrested by the sand-tight jetty just completed.

The removal of 10,000 cubic yards of sand from behind the breakwater and from the creek outlet will give an effective depth of 7 to 8 feet at extreme low water, and will make the harbor available for the small vessels suited to the coasting trade.

OPERATIONS.

An examination by borings was made along the line of the proposed sand-tight jetty in the fall of 1891, to see if it would be possible to drive piles there. The results indicated that work of this kind would be entirely practicable. Accordingly, material was purchased and a party was sent to Pultneyville to construct about 200 feet of this work. Operations were begun November 19 and continued until January 9, 1892, when it was completed. The Wakefield patent sheet piling was used, and the owner was paid a royalty of 20 cents a running foot of completed structure for the use of this patent. The piles as used here were built up of three oak planks, 12 inches wide and 2 inches thick, bolted so as to form a tongued-and-grooved pile of proper length. They can be driven in close contact, and form a structure that is nearly water-tight.

This particular form of patent sheet piling has been elsewhere used on the public works, and has been described in the Reports of the Chief of Engineers. The piling is stregthened by oak wale pieces, which are below the line of no decay, and is tied back by iron rods 12 feet long to logs in the bottom, the object of this being to prevent the piling from being pushed over towards the channel by sand which will probably gather behind it.

The cost was $1,555.85, or $7.78 per running foot complete.

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The items are as follows:

Labor	$739.49
Lumber	653.30
Stone (and protecting the outer end)	24.50
Other materials and tools	98.96
Use of patent right	39.60
Total	1,555.85

In addition to this, $62.63 was expended during the year for engineering and office expenses.

REMARKS.

A good deal of dredging has been done in the past before the construction of the bulkhead, but the moving sand has reduced the available depth between the jetties to about 7 feet; and along the breakwater and at the mouth of the creek the channel is only three or four feet deep.

This renders it impossible for vessels to approach the wharves and warehouses which are within the mouth of the creek, and therefore the harbor is well-nigh useless. The few vessels that do come here are forced to lie at the outer end of the jetty channel in an exposed position and transfer their cargoes to small boats. As a result commerce has almost disappeared.

The superstruction of the breakwater and a greater part of that of the jetties is now very much decayed. It ought to be renewed at once. If this was done, and the sand-tight bulkhead completed and the channel thoroughly dredged out, it would complete the proposed improvement and make valuable the work already done. It would afford a safe and good harbor for small vessels (the class that most need it) between Great Sodus Bay and Charlotte, a stretch of exposed coast some 35 miles long, which now offers no shelter whatever. There is no other place in my district where a small amount of money would produce such marked benefit.

The amount now available, being less than $400, is too small to enable me to undertake any of this work.

Name of harbor, Pultneyville, N. Y.; collection district, Genesee, N. Y.; nearest light-house, Great Sodus, New York; nearest work of defense, Fort Ontario, N. Y.

Money statement.

July 1, 1891, balance unexpended	$1,987.71
June 30, 1892, amount expended during fiscal year	1,618.48
July 1, 1892, balance unexpended	369.23
Amount appropriated by act approved July 13, 1892	1,000.00
Amount available for fiscal year ending June 30, 1893	1,369.23
Amount (estimated) required for completion of existing project	9,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	9,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Pultneyville Harbor, New York, during fiscal year ending June 30, 1892.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.	
	Number.	Registered tonnage.	Number.	Registered tonnage.
Home, on lake	4	300	.....	.....
Foreign, on lake	.....	.....	4	208
Total	4	300	4	208
American owned	4	300	1	76
Canadian owned	.....	.....	3	132

Sum total, 8 arrivals; 508 registered tonnage.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.	
	Number.	Registered tonnage.	Number.	Registered tonnage.
Home, on lake	4	300	1	76
Foreign, on lake	.....	.....	3	132
Total	4	300	4	208

Sum total, 8 departures; 508 registered tonnage.

Greatest draft of vessels, 7 feet.
Greatest tonnage, 76 registered tons.
Greatest load, 92 net tons.

Receipts and shipments by lake at Pultneyville Harbor, New York, during fiscal year ending June 30, 1892.

Trade.	Receipts.			Shipments.	
	Passengers.	Merchandise.	Lumber, etc.	Passengers.	Fruit.
	No.	*Net tons.*	*Tons.*	*No.*	*Tons.*
Home on lake	1,000	.....	.....	1,000	.....
Foreign on lake	.....	6	103	.....	56
Total	1,000	6	103	1,000	56

For the purpose of reduction to tons weight the following is assumed: Barrels oil, 7 equal 1 ton; M lumber, 1 equals 1½ tons; crates fruit, 20 equal 1 ton; railroad ties and poles, 12 equal 1 ton; cord wood and posts, 1 equals 1½ tons; live animals, 4 equal 1 ton.

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OO3.

IMPROVEMENT OF HARBOR AT GREAT SODUS BAY, NEW YORK.

OBJECT.

To secure a navigable channel from Lake Ontario to Great Sodus Bay with a depth of 15 feet.

Great Sodus Bay is 5 miles long, 2 to 3 miles wide, is deep and land-locked, and is situated midway between Oswego and the Genesee River. It is the coal-shipping port on Lake Ontario for the Pennsylvania Railroad.

PROJECT.

1828.—To contract the entrance to Great Sodus Bay to 470 feet by breakwaters extending from east and west shores and to define and project a channel 470 feet wide by piers extending to deep water in Lake Ontario.

1882.—To extend the piers to the 15-foot curve in the lake and to dredge the channel between them to 15 feet depth at extreme low water.

PRESENT WORKS.

The project has been completed, except that the east jetty lacks 800 feet of reaching the curve of 15 feet at extreme low water and that the channel has not been dredged to 15 feet for its full width.

The dredging has been confined to the western half of the space between the jetties, and the channel thus made has not been permanent.

Excavation of the full width (except 50 feet next the jetties) to 15 feet at extreme low water is now in progress.

The piers and jetties which contract the entrance and define and shelter the channel were originally built in 1829–1834. They were started from the west and the east sides of the entrance, naturally about 4,000 feet wide, and were extended toward the center, where they were continued northward by parallel jetties, 470 feet apart across the 8-foot bar, from deep water in the bay to the deep water in the lake.

These piers and jetties defining and sheltering the channel were built in 1829–1834, and were composed of cribs of timber, each 18 feet wide and 30 feet long, sunk, end to end, upon the natural sand and gravel bottom in as close contact as practicable by filling them with loose stone.

The cribs were formed of round logs, hewed flat, framed together and bolted with iron drift bolts and wooden treenails. They appear to have had floors of slabs, and were allowed to settle into the natural sandy bottom for part of the season before building upon them the continuous superstructure of hewed timber. These old cribs, in part or whole, are still in place, and are sound below mean water level.

The different portions of the works may be described as follows:

(*1*) *West breakwater.*—This has a total length of 2,200 feet. It was built 18 feet wide, with a superstructure of same width, in 1829–1834.

The cribs were each 18 feet wide and 30 feet long, and starting at the beach line gradually increased in depth to 8 feet where they joined the jetty.

Section A, 1,693 feet long from west shore eastward. The cribs

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were built in 1829–1834, and are still sound. The superstructure was built at the same time, was never renewed, and has long since decayed. The whole structure is buried and covered by the accretion of the beach sand outside it, and its maintenance has been unnecessary.

Section B, 241 feet long in continuation of the last section. The cribs were built in 1829–1834, and are still sound. The superstructure was not renewed, for the same reasons given above, until 1888, when the owner of the adjoining tract of land formed by accretion renewed it 14 feet wide and 4 feet high.

Section C, 266 feet long in continuation of the last section to the west jetty. The cribs were built in 1829–1834, and are still sound. The superstructure was renewed by the United States in 1877–1878 207 feet, 14 feet wide and 59 feet next the angle, 18 feet wide. Upon the latter stands the inner range beacon and the United States water gauge.

(2) *West pier or jetty.*—This is 1,580 feet long, 18 to 20 feet wide, as follows:

Section A, from shoulder-angle at junction with breakwater, 975 feet northward, 18 feet wide. The crib structures built in 1829–1834 were wrecked to an average depth of 4½ feet below mean water level between 1857–1866. Had new cribs sunk on top of the wrecked ones 1866–1868. Are now sound, but in bad condition, allowing free passage of sand into the channel.

The superstructure was built of timber filled with loose stone at the same date as the cribs and was continuous over them. It received general repairs in 1845 and again in 1852, but was all decayed and destroyed prior to 1866, when its renewal was begun, and was completed in 1869.

In 1877, 150 feet from the angle northward was again renewed, and in 1880 the remaining 825 feet was also renewed.

Section B from the last section northward is 285 feet long and 18 feet wide. The cribs were built is 1829–1834, and otherwise have the same history as the last section, and were rebuilt as they were in 1866–1868. The superstructure was built upon them in 1866–1868 and was first rebuilt in 1889.

Section C from the last section northward is 134 feet long and 18 feet wide, the outer 40 feet being a pier head 40 feet square. This section was built in 1869, and was formed of three cribs, each 30 feet long and 18 feet wide, and a pier head at the outer end 40 feet square, having an open central space 18 feet square for a light-house foundation. The cribs were built of sawed hemlock timber 12 inches square and had tight floors laid upon screw-bolted grillages. The foundation was prepared for these cribs by dredging a trench to about 12 feet depth, in which they were sunk. The superstructure, five courses high of 12 by 12 inch pine timber, was built upon them in 1869, but had to be leveled and redecked in 1871, the structure having settled. The superstructure was next renewed in 1889, when the pier-head crib was cut down to line of no decay and decked at that level with solid timber.

Section D extends from the last section 185 feet northward to the 15-foot curve of extreme low water. This section is 20 feet wide and was built complete in 1883. The cribs were each 30 feet long and 20 feet wide and 13 feet deep, and were formed of sawed 10-inch by 12-inch timber (the lower 11 feet of hemlock and the upper 2 feet of pine) and had partly open floors made of 3-inch plank laid 18 inches apart upon screw-bolted grillages. The cribs were placed upon a riprap foundation 40 feet wide and 4 to 5 feet thick, deposited in a trench dredged

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for the purpose, costing 50 cents per cubic yard for the excavation and $1.30 per cubic yard for the riprap in place.

The superstructure was built upon the cribs the same season and consisted of four courses of 10-inch by 12-inch pine timber (with a tight deck of 3-inch pine plank) filled with loose stone.

In 1891 the outer end was cut by a barge down to 6 feet below water, requiring the renewal of the end of the crib and superstructure.

3. East breakwater.—This has a total length of 1,651 feet from Charles Point on the east side of the bay westward to join the east jetty. The original structure, built in 1829–1843, was not repaired nor renewed until 1874. The superstructure and cribs were then gone to about the level of the surface of the bar in which the cribs were embedded, which was at an average depth of 1 foot below extreme low-water level.

Section A, the shore arm, from Charles Point to the lake arm, is 215 feet long and 14 feet wide, with 5 feet total height of cribs and superstructure. It was built in 1884 and sunk upon the natural bottom in about 2 feet depth of water. It is in good order.

Section B is 511 feet long and 14 feet wide; is part of the original structure built in 1829–1843.

It was first renewed in 1874, when four courses of continuous superstructure was framed together of 12-inch by 12-inch pine timber, its lower courses being securely bolted to the remains of the old cribs; the top being at 4 feet above extreme low water. In 1877–1878, the deck plank and joints being decayed and broken but the side timbers fairly sound, the top was renewed by adding one course of 10-inch by 12-inch pine timber and laying a new deck.

Section C is 415 feet long, 14 feet wide, and has a history similar to the last described section. Its first renewal was made in 1870–1872, and its next and last renewal in 1887–1888.

Section D is 172 feet long, 14 feet wide, was built in 1829–1834, and was first renewed in 1870, but not since then. The superstructure is much decayed.

Section E is 264 feet long, 14 feet wide, was built in 1829–1834, and was first renewed in 1876. The superstructure has not since been renewed until 1891, when the western 126 feet was renewed in parapet form, the half toward the harbor being 4⅓ feet above extreme low water, and the lake half 7⅓ feet above the same plane.

Section F is 74 feet long to the east jetty, and is 18 feet wide. It was built in 1829–1834; was first rebuilt in 1876, and was next renewed in 1891, when it was built in parapet form as described in the last section.

(4) *East pier or jetty.*—This is 1,294 feet long from its junction with the east breakwater northward into the lake to the 10½-foot curve of extreme low water. It was originally built 18 feet wide in 1829–1834, of the same style of crib work as formed the west jetty, and was extended 20 feet wide in 1883–1884. Its details are as follows:

Section A from angle with east breakwater 440 feet northward was built in 1829–'34. It was first repaired in 1853 by renewal of superstructure, and this was again done in 1875–1876.

In 1891 the superstructure was again renewed, this time in parapet form with the half next the channel 4⅓ feet above extreme low water, and the other half 3 feet higher.

Section B is 500 feet long and 18 feet wide, and was originally built in 1834. The superstructure was first repaired in 1853, but was destroyed between that date and 1869, when it was necessary to rebuild cribs and superstructure from an average depth of 4½ feet below mean

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water level to about 4 feet above the same plane. The superstructure was last rebuilt in 1890, not in parapet form.

Section C is 154 feet long and 20 feet wide, and was built complete in 1883; the details of its construction being the same as those of Section D of the west jetty, which has already been described.

Section D is 200 feet long and 20 feet wide, and was built complete in 1885. It was formed of cribs each 50 feet long, 20 feet wide, and 12½ feet high, built of 10 by 12 inch hemlock timber with two upper courses of pine timber.

The floors were built in the center only, and were omitted for a width of 4 feet along each side. The cribs were sunk upon a riprap foundation 40 feet wide, deposited in a trench dredged for the purpose in the sandy bottom.

The continuous superstructure of four courses of pine timber was built upon the crib in 1885. The cribs forming this work differ from previously built cribs at this harbor in being 50 feet long each, instead of 30 feet; in having a riprap foundation; in having partly open floors; also in having, besides the usual drift-bolt fastenings, 6 vertical pine posts in each crib, extending from the grillage bottom to the top of the superstructure and screw-bolted to each timber; and they have a tight deck, laid longitudinally, directly upon the top set of cross-ties. This completes the description of the structures of this harbor, except the sheet-piling, which has been placed along the west jetty to arrest the drift of beach sand through it into the channel. Of this sheet-piling the first section was driven in 1877 along the west face of the west jetty, beginning 150 feet north from the shoulder angle and extending 50 feet northward. In 1887 the second section was built, beginning at the north end of the first and extending 245 feet northward along the west face. At this point the substructure of cribs projected outside the line of the superstructure about 3 feet, so that it was necessary to locate the third section of sheet-piling on the east face, where it was extended 367 feet northward along the channel face of the jetty during 1888; a tight cross bulkhead being driven between two cribs to unite the two sections.

The sheet-piling consists of 4-inch by 12-inch oak plank, each 20 feet long, driven to a depth of 14 to 15 feet below extreme low-water level, and secured to the superstructure of the jetty by 1-inch lag screws through each pile and also by 6-inch by 12-inch continuous oak wale pieces, screw-bolted through the piles to the timbers of the crib work.

To arrest sand movement into the channel there was also built in 1877 and 1880 upon the west sand beach, where it had formed against the west jetty, a system of overlapping sand-catch fences of a total length of 760 feet. These fences have been effective, but they can not be maintained beyond high-water line, and there is generally a wide space of sand between them and the water, from which the prevailing westerly winds blow the sand across the jetty. This is the source from which comes a considerable portion of the sand which refills the channel.

CHANNEL.

1829.—The space 470 feet wide between the jetties had a natural depth of 8 feet in October, 1829. This was the actual depth at that time, when the water level must have been at least 1 foot, and was probably 2 feet, above extreme low water, this being the average stage of lake level at this time of year. No plane of reference for lake water

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level was established until 1837, when the present accepted extreme low-water level was determined at Oswego and fixed as the zero of the gauge, whose readings have since been daily observed in feet and hundredths above this zero.

The records of channel depths in the various reports are much confused during recent years, as well as formerly, by variously stating the depth as at ordinary low-water level, or at ordinary water level, or as the actual depth at a given date. In this report all such reference will be reduced to the plane of extreme low water without further comment.

1836.—The first dredging was done at Great Sodus Harbor in 1836, and was continued during 1837 and 1838, $45,390 being thus expended.

1838.—The result was to form a channel 100 feet wide, 1,500 feet long, with 11½ feet depth, by removing about 30,000 cubic yards of gravel and sand.

1844.—In August, 1844, this channel was found to have shoaled to 9 feet depth.

1856.—The next dredging was done in 1856, when 6,233 cubic yards of sand was removed at a cost not stated.

1867.—Nothing more was done until 1867, when renewal of the jetty was begun and dredging was done under its shelter; 9,200 cubic yards were then dredged at 24 cents per yard.

1868–'69.—The dredging was continued in 1868 and 1869, completing a channel next the west jetty, 200 feet wide, 1,700 feet long, and 10 feet deep, by removing about 40,000 cubic yards additional.

1870.—In 1870 the sand had again drifted into this 200-foot channel to such an extent as to reduce it to 8 feet depth for its west half, and 4 to 5 feet depth for its east half, the undredged eastern 270 feet of the space between the jetties varying from 2 feet at the inner end to 7 feet at the outer end.

1873.—In 1873, 19,000 cubic yards of sand were removed at 35 cents per cubic yard measured in position, again making the channel 9 feet deep for 150 feet next the west jetty, and this was continued in

1874 by removing 44,977 cubic yards of sand at 22½ cents, scow measurement, and again making the 200-foot channel 9 to 11 feet deep.

1881.—No further dredging was done until 1881, when the channel had again shoaled to a governing depth of 8 feet and dredging was resumed.

1882.—During 1881 and 1882, 42,050 cubic yards were removed at 23 cents per cubic yard in scows, making a channel 2,300 feet long, 120 feet wide next the west jetty, and 11½ feet deep.

1886.—In 1886 dredging was again needed and 13,224 cubic yards were removed at 16 cents yer yard, making a channel 50 feet wide and 12 feet deep.

1887.—In 1887 the depth was again reduced to 9 feet and a centrifugal pump was employed to take the sand from the channel and deliver it on the other side of the west jetty. Thirteen thousand cubic yards of sand were thus removed, at 12½ cents per cubic yard, making 10¼ feet deep for 50 feet width.

1889–'90.—In 1889 and 1890 a dipper dredge was again employed, 40,942 cubic yards of sand, gravel, and cobblestones were removed, at 18 cents per cubic yard, scow measurement, and a navigable channel was again made 100 feet in width, 2,000 feet long, and 15 feet deep, located 30 feet from the west jetty.

1892.—In 1892 this was found to have again filled so that there was but 8¾ feet depth, and the new United States dredge *Frontenac* began work on May 30 to improve the channel.

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The following summary shows the total dredging which has been done and the sums expended therefor. For the first item, the number of cubic yards is computed from the dimensions of the channel dredged, and the cost given is the sum of the appropriations for 1836, 1837, and 1838, less $1,000 used for repairs, the reports stating that operations for those years were otherwise confined to dredging:

Date.	Cubic yards.	Rate per yard.	Cost.
1836, 1837, 1838	33,000	$1.37	$45,390
1856	6,233		
1867	9,200	.24	2,208
1868, 1869	40,000	.24	9,600
1873	19,000	.35	6,250
1874	44,977	.22½	10,120
1881, 1882	42,000	.23	9,660
1886	13,224	.16	2,116
1887	13,000	.12½	1,626
1889, 1890	40,942	.18	7,370
Total	261,576		94,340

Comparison of a detailed survey made in 1870 with another survey made in 1892 by the same assistant engineer serves to give a definite idea of the effect of the dredging done during the interval.

It has been repeatedly stated in the annual reports that the refilling of the dredged part of the channel was caused by the movement of sand into the cut from the undredged part.

Comparison of the surveys show that between 1870 and 1892 the undredged part has deepened for an average of 3 feet over an area 1,000 feet long and 270 feet wide. This indicates a movement of 30,000 cubic yards of material into the cuts made at different times. The remainder, 142,000 cubic yards, has come through and over the west jetty. Much of this movement through the jetty was made possible by the unusual manner in which the renewal of the wrecked cribs below water was done in 1867–'68. The original cribs had then been destroyed to depths varying from 2 to 10 feet below water (averaging 4½ feet). There were sunk, on top of the old substructure, cribs whose floor plank extended across from side to side, placed 3 inches apart instead of close together. These spaces between the floor plank formed, just above the level of the sandy bottom, clear passages for sand through the jetty, and through these spaces the sand has flowed whenever there were waves to move it.

OPERATIONS.

The work of renewing the superstructure in the parapet form, according to the most recent and approved plans, on section A of the east jetty, 440 feet long; section F of the east breakwater, 74 feet long, and the western 126 feet of section E of same, in all 640 feet, was begun August 9, 1891, and finished November 6 of the same year. The lumber and iron required for the work were purchased by public notice and sealed proposals; the other material and labor required was secured in open market.

In addition to the foregoing the same party repaired the old lighthouse crib on the west face of the west jetty, and also placed some 80 cords of stone in the portion of the east jetty that was rebuilt the previous year and which was not wholly filled with stone at that time. The party also put up a tool house for use in connection with the work

at the shore end of the west jetty. Old material taken from the pier which was being repaired was used in its construction.

The total expenditure for the foregoing work was $6,481.78, divided as follows:

Labor	$3,350.76
Lumber	2,668.09
Iron	413.55
Other material and tools	49.38
Total	6,481.78

There was also expended for engineering and office expenses during the fiscal year, $1,243.62. Under the authority of the Chief of Engineers $4,000 was expended from the appropriation for this work toward the purchase of a dredging plant for use in the harbors in this district.

On the 29th of May, 1892, the United States dredging plant was sent to Great Sodus Harbor to deepen the channel between the jetties. It continued to work until the end of June. It was much delayed on account of breaking its spuds, which had been badly worn on other work, and also by breaking a casting which could not be quickly replaced. Notwithstanding this, however, it removed, up to June 30, 11,219 cubic yards of material. The exact cost of the work can not be given at the present time. The total sum paid during the fiscal year in connection with this work was $500.66, and there was outstanding at the end of the year $1,235. This amount is estimated, as there are some small bills for supplies which have not yet been received and examined. This would make the total cost per cubic yard a little less than 15½ cents, which compares favorably with the cost of previous work done under contract. The price, 15½ cents, is really too large, because it includes the cost of rope and other similar material which can be used for several seasons.

The dredge will be forced to stop work at this place early in July on account of lack of funds.

REMARKS.

It appears from the records that a large amount of dredging has been done in this channel in the past, and it also appears that this dredging has always been done near the west jetty, the side from which the winds and waves bring in the sand. This has put the channel in the place where it could be most quickly filled.

The sand, whether blown over the jetty by the wind or washed through it by the waves, would most of it come to rest within 200 feet of the west jetty, or, in other words, in the west half of the channel. The surveys confirm this and show that the eastern half of the channel, where no dredging has ever been done is deeper now than it was 30 or 40 years ago. In view of this, it seems best to me to begin dredging on the east side of the channel and to gradually widen towards the west. In the meantime every effort should be made to keep the sand from getting into the channel, both by inducing a growth of vegetation above the high-water line along the shore of the west of the channel and by making the jetty perfectly sand-tight below water.

I think the pier should be extended to the 15-foot curve as rapidly as the means provided will allow and that the channel should be dredged to its full width in the manner before stated.

The work will cost $58,000. In addition to this there should be available every year the sum of $5,000 for the maintenance of existing works

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by renewing from time to time, as required, the perishable portions of the structures.

Name of harbor, Great Sodus Bay, New York; collection district, Oswego, New York; nearest light-house, Big Sodus, New York, a fixed white light of the fourth order, varied by a white flash every 2 minutes, on a bluff three-fifths mile west of the entrance to the bay; a fixed white light of the sixth order 180 feet inside of the outer end of the west pier, and a fixed red light of the sixth order at elbow of west pier. Nearest work of defense, Fort Ontario, New York.

Money statement.

July 1, 1891, balance unexpended	$13,763.80
June 30, 1892, amount expended during fiscal year	12,226.06
July 1, 1892, balance unexpended	1,537.74
July 1, 1892, outstanding liabilities	1,235.00
July 1, 1892, balance available	302.74
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	15,302.74
Amount (estimated) required for completion of existing project	43,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	40,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Great Sodus Harbor, New York, during fiscal year ending June 30, 1892.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	29	4,605	17	2,947	19	7,144
Foreign, on lake	1	277	61	9,787	2	643
Total	30	4,882	78	12,734	21	7,787
American owned	29	4,605	4	854	7	1,817
Canadian owned	1	277	74	11,880	14	5,970

Sum total, 129 arrivals; 25,403 registered tonnage.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	28	4,636	11	1,935	5	1,355
Foreign, on lake	4	391	66	10,600	16	6,432
Total	32	5,027	77	12,535	21	7,787

Sum total, 130 departures; 25,349 registered tonnage.

Greatest draft of vessels, 10½ feet.
Greatest tonnage, 541 registered tons.
Greatest load, 993 net tons of coal.

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Receipts and shipments, by lake, at Great Sodus Harbor, New York, during fiscal year ending June 30, 1892.

Trade.	Receipts.				Shipments.			
	Passengers.	Grain.	Railroad ties.	Lumber.	Passengers.	Grain.	Merchandise.	Coal.
	No.	*Net tons.*	*Tons.*	*Tons.*	*No.*	*Net tons.*	*Net tons.*	*Net tons.*
Home, on lake	10	308	.....	.....	1,303	183	54	463
Foreign, on lake	.....	1,309	1,799	189	.....	.....	16	31,711
Total	10	1,617	1,799	189	1,303	183	70	32,174

Navigation closed November 26, 1891; navigation opened April 18, 1892.

For the purpose of reduction to tons weight the following is assumed: Barrels oil, 7 equal 1 ton; thousand feet lumber, 1 equals 1½ tons; crates fruit, 20 equal 1 ton; railroad ties and poles, 12 equal 1 ton; cordwood and posts, 1 equals 1½ tons; live animals, 4 equal 1 ton.

OO4.

IMPROVEMENT OF HARBOR AT LITTLE SODUS BAY, NEW YORK.

OBJECT.

To secure a channel from Lake Ontario into Little Sodus Bay of navigable width and of depth not less than 15 feet at extreme low water.

Little Sodus Bay is 2 miles long, three-fourths of a mile wide, is deep and land-locked, and is situated midway between Oswego and Great Sodus, or 13 miles west of Oswego. It is the coal-shipping port on Lake Ontario for the Lehigh Valley Railroad.

PROJECT.

To contract by breakwaters the entrance to the bay to a width of 250 feet and maintain a channel 200 feet wide and 15 feet deep at extreme low water by parallel piers.

PRESENT WORKS.

The project has been completed, except that the west and the east jetties lack 200 feet and 465 feet, respectively, of reaching the 15-foot curve and that the whole of the channel between the jetties has not been dredged to 15 feet, 12 feet at extreme low water being the governing depth.

The undredged part of the channel is the outer 500 feet of the space between the present jetties and 200 feet additional beyond the end of the west jetty. The material is tough hard-pan, requiring blasting before it can be dredged.

The breakwaters and jetties which contract the entrance and define and shelter the channel were begun in 1854, though the works now forming the harbor have been built since 1867. They consist of crib-work breakwaters extended from the west and the east sides of the entrance (naturally 2,500 feet wide in 1867) upon the gravel bar, which

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is characteristic of this and of all the bays on the south shore of Lake Ontario.

The breakwaters were built to the sides of the natural cut through the bar (which was 1¼ feet deep in 1853 and 5½ feet deep in 1866), and were thence extended north to deep water in the lake by parallel jetties 250 feet apart.

These structures were formed of cribs each 20 feet wide and 30 feet long, sunk end to end upon the natural bottom in as close contact as practicable by filling them with loose stone gathered from the shores of the bay and lake, and by dredging gravel and dumping it into them.

The cribs were formed of sawed hemlock timber 12 inches square, and 10 by 12 inches, which was framed together and bolted with iron bolts. The cribs had tight plank floors and the earlier ones were allowed to settle into the natural gravel and sand bottom for part of the season before building the continuous superstructure of 12 by 12 inch pine timber, also filled with loose stone. For the later cribs, a foundation was prepared by dredging a trench or by depositing riprap.

At each side of the bay the junction of the breakwaters with the shore was effected by stake and fascine structures, intended to aid the accretion of drift.

The different portions of the work are described as follows: In every case where depth of water is mentioned in this report, the depth at extreme low-water level, or below the zero of the Oswego gauge is meant.

(*1*) *West breakwater.*—The original structure was built in 1868, and was a peculiar one, specially designed for this place. It was of triangular cross section, with 13 feet base and 13 feet sides, built in separate sections, 25 feet long, of 6 by 6 inch hemlock frames, planked inside with 2-inch hemlock plank, the whole filled with loose stone and sunk upon the crest of the bar at depth of half a foot to 2 feet.

Its total length from the west shore to the west jetty was 650 feet. The breakwater was built in 1868, and was destroyed the same year.

In 1870–'71 the present rectangular crib-work structure, 469 feet long and 10 feet wide, was built 30 feet outside of and parallel with the original one. It is still in place, though much decayed; all but 90 feet adjoining the west jetty is buried beneath the accretion of the west beach, and this 90 feet was repaired in 1887. In 1887, there was built in front of the breakwater and adjoining the jetty 200 feet of stake and fascine work. This has gathered the gravel, and it is probable that minor repairs to 50 feet of the breakwater is all that will be here needed in future.

(*2*) *West pier or jetty.*—This is 1,960 feet long and 20 feet wide, extending across the bar north to deep water in the lake.

Section A is 186 feet long, 20 feet wide, and was built with its superstructure in 1854.

The cribs forming the substructure were each 20 feet wide and 30 feet long, sunk end to end upon the natural gravel bottom in as close contact as practicable by filling them with loose stone. The cribs were formed of flatted logs framed together and bolted with iron bolts and wooden tree nails.

They appear to have had floors of slabs, and to have been allowed to settle into the natural gravel bottom for part of the season before building upon them the continuous superstructure of hewed timber.

These cribs are still in place and are sound below mean water level. The superstructure was never renewed and has disappeared. The

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breakwater and the beach line being outside of this portion of the jetty, it is no longer necessary to keep it in repair.

Section B is 50 feet long and 20 feet wide, extending north in prolongation of section A. It was originally built in 1854 when the last section was built, but instead of being abandoned as that has been, its superstructure was renewed in 1867, and has since been maintained and forms the inner end of the west jetty. The west breakwater joins it 40 feet north of its south end.

Section C is 860 feet long in prolongation of the last section north, is 20 feet wide, and was built with superstructure in 1867–'68. The cribs forming the substructure were each 20 feet wide and 30 feet long, with tight floors, and were sunk upon the natural bottom, in depths increasing from 6 to 11 feet at extreme low-water level, by partly filling with loose stone. After building the continuous superstructure of five courses of 12 by 12 inch pine upon the cribs, the filling was completed by dredging the channel to 12 feet depth close beside the cribs, and dumping the sand and gravel directly into the crib work from the dipper. The cribs settled into the cut so that the channel side was under water and the structure nearly rolled over.

In 1870–'71 it was necessary to remove the deck, build up the channel side vertically for 3 feet, and relay the deck. No future dredging can safely be done nearer to this section than 30 feet.

In 1889 the superstructure was first renewed, built this time with 10 by 12 inch pine timber, and with longitudinal tight deck.

Section D is 150 feet long and 20 and 30 feet wide. It was built in 1870–'71 in prolongation of the preceding sections. The substructure was formed of four cribs, each 20 feet wide and 30 feet long, and one crib 30 feet square for a pier head. They were built of sawed 12 by 12 inch hemlock timber, with tight floors, and were sunk upon the natural bottom at depths of 10 to 11 feet by filling with loose stone. The continuous superstructure of four courses of 12 by 12 inch pine timber was built upon the cribs the same season.

The superstructure was first renewed upon it in 1889–'90, at the same time when renewal was made upon sections B and C.

Section E is 242 feet long in prolongation of last section; is 20 feet wide, and was built complete in 1881.

The cribs forming the substructure are each 30 feet long, 20 feet wide, and were buit of 10 by 12 inch sawed hemlock timber, framed together and bolted with 1⅛ iron drift bolts. The floors are of 3-inch hemlock plank, laid 18 inches above the bottom, and with 3-inch spaces, upon a screw-bolted grillage.

The cribs were filled with loose stone and sunk end to end in close contact upon the natural bottom, having an average depth of 11 feet. There was no dredging or riprap for their foundation. The continuous superstructure of four courses of 10 by 12 inch pine timber was built upon the cribs the same season and filled with loose stone. The deck was of 3-inch pine plank, laid crosswise and close together.

Section F is 272 feet long in prolongation of the last sections, is 20 feet wide, and was built complete in 1883. The cribs were similar to those of the last section, except that their floors were laid 30 inches above the bottom and with 18-inch spaces. These cribs were also sunk upon the natural bottom, having an average depth of 12 feet without dredging or riprap for foundation. The bottom was leveled for the first crib only by throwing in stone.

The continuous superstructure of four courses of 10 by 12 inch pine was

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built the same season, and was of 3-inch pine plank, laid crosswise close together.

Section G is 200 feet long in prolongation of the last section, is 20 feet wide and was built complete in 1885. The cribs differ materially from the former ones. Foundation was prepared for them in 1884, by forming upon the natural bottom a mass of random stone 3 feet in thickness and 30 feet in width. Upon this, in 1885, were sunk the cribs, which were each 50 feet long and 20 feet wide and 14 feet deep and were built of 10 by 12 inch sawed hemlock timber, except the two upper courses, which were of pine. In addition to the usual drift-bolt fastening each crib also had six vertical pine posts extending from the grillage bottom to the top of the superstructure and screw bolted to each timber. The floors were of 3-inch hemlock plank, 36 inches above the bottom, but not laid clear across, an open space of 4 feet width being left along each side to permit the stone filling to settle. This last feature has proved to be a radical defect, resulting only in a waste of stone filing and requiring (in 1888) the repair of the outer end, from which all the stone had escaped. It was necessary to build and sink within the crib four interior cribs to close these openings, and then to refill the outer end of the crib with stone.

The superstructure of four courses of 10 by 12 inch pine, which was built upon the crib the same season, 1885, has a longitudinal tight deck of 3-inch pine, laid directly upon the top set of cross-ties without the usual deck joints. This section, upon which the light-house stands, completes the west jetty.

(3) *East breakwater.*—This is 1,850 feet long, consisting of 1,680 feet of shallow crib work, is 20 feet wide, placed upon the crown of the bar in depths varying from half a foot above extreme low-water to 2½ feet below the same plane. It extends from near the east side of the bay to the east jetty, its junction with the east shore being effected by 170 feet of stake and fascine work.

Its details are as follows:

Section A is 170 feet long and 8 feet wide and was built in 1885, from the east shore to the crib-work breakwater, which it joins 50 feet west of the east end.

It consists of stakes and wire-bound fascines, made from the trunks and branches of hard-wood brush, the whole paved with stone gathered from the lake shore. It has stood without attention and is covered by the accretion of sand and gravel.

Section B is 150 feet long and 20 feet wide and was built in 1878, forming the east end of the breakwater.

It is formed of 5 cribs, each 30 feet long, 20 feet wide, and 3 feet deep, sunk upon the natural bottom. The cribs were built of 10 by 12 inch hemlock timber, with a close floor of hemlock plank one foot above the bottom.

The continuous superstructure of two courses of 10 by 12 inch pine timber was built over the cribs the same year and the whole filled with loose stone and decked with 3-inch pine plank laid cross-wise, with 3-inch spaces. The deck was 4½ feet above extreme low water. It has not since been renewed, except its western 50 feet, which was included in the portion rebuilt in parapet form in 1891.

Section C is 750 feet long and 20 feet wide. It was originally built in 1875, its cribs and superstructure being of the same description as those of the last section. Its superstructure was not renewed until 1891, when it was rebuilt in parapet form. The parapet on the lake

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front is 9 feet wide and 3 feet higher than the harbor front, which was rebuilt at 4⅓ feet above extreme low-water level for 11 feet width.

The whole was filled with loose stone and decked with 3-inch longitudinal pine plank, laid tight.

Section D is 540 feet long, 20 feet wide, formed of cribs and superstructure like those of the last section, and was built in 1874. The superstructure was renewed in the parapet form just described during 1889–'90.

Section E is 240 feet long, 20 feet wide, formed of cribs and superstructure like those of the last sections, and was built in 1873. The superstructure was renewed in the parapet form just described during 1889–'90 in connection with the last section. This joins the east jetty, with which its superstructure is bonded.

(*4*) *East pier or jetty.*—This is 1,510 feet long from the west end of the east breakwater across the bar to 11½ feet depth in the lake. It is located parallel with the west jetty and 250 feet from it. The substructure cribs of the inner 512 feet were placed in a trench dredged 30 feet wide in a gravel bar to a depth of 8 feet below extreme low water; the next 757 feet were placed in a trench dredged to 10 feet below extreme low water, and the remaining 241 feet were placed upon the natural bottom at depths of 10 to 11 feet. The details are as follows, beginning at the inner end:

Section A is 512 feet long, 20 feet wide, and was built in 1872–'73. The cribs forming its substructure were built of 12 by 12 inch sawed hemlock timber framed and drift-bolted together. They had close floors of hemlock plank laid 18 inches above the bottom upon the timbers of a screw-bolted grillage.

Each crib was 30 feet long, 20 feet wide, and 9 feet deep. The site was prepared for the cribs by dredging across the gravel bar a trench 30 feet wide to 8 feet below extreme low water, where the natural depths were 2 feet at the inner end, increasing gradually to 6 feet at the outer end. The cribs were sunk in this trench by filling them with loose stone.

The continuous superstructure of 4 courses of 12 by 12 inch pine timber was afterward built upon them and was also filled with loose stone and was decked with 3-inch pine plank laid cross-wise, with 3-inch spaces. The superstructure was not repaired until 1887, when it was renewed by building 4 courses of 10 by 12 inch pine timber, decked with 3-inch longitudinal plank laid tight.

Section B is 757 long in prolongation of the last section, 20 feet wide, and was built in 1881 and 1882. Each crib was 30 feet long, 20 feet wide, and 12 feet deep, the lower 10 courses of hemlock and the upper 2 courses pine. The cribs had close floors of 3-inch hemlock plank laid 18 inches above the bottom upon the timbers of a screw-bolted grillage.

The site was prepared for the cribs by dredging a trench to 10 feet below extreme low water, where the natural depth was from 6 to 10 feet.

The continuous superstructure of 4 courses of 10 by 12 inch pine timber was built the same season, filled with loose stone, and decked with 3-inch pine plank laid cross-wise, but tight together. It has not since been renewed.

Section C is 241 feet long in prolongation of the last section, is 20 feet wide, and was built complete in 1883. Each crib was 30 feet long, 20 feet wide and 12 feet deep, the same as those of the last section. The foundation was not prepared for them by dredging or riprap, except that the bottom was leveled for the first crib by throwing in some stone.

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The natural depth when the cribs were placed was 10 to 11 feet at extreme low water. The superstructure was built the same year, similar to that of the last section.

This completes the present east jetty, which is, however, about 500 feet shorter than its proposed length.

CHANNEL.

Prior to beginning the construction of jetties, there was no permanent natural channel across the bar which closed the entrance to the bay.

The general width of this bar from deep water within the bay to deep water in the lake outside was from 600 to 900 feet between 6-foot curves, about 2,000 feet between 12-foot curves and 2,600 feet between 15-foot curves. These and all depths stated in this report are at extreme low-water level, which coincides with the plane of zero of the Oswego gauge which was established at extreme low-water level in 1837.

The natural depths upon the crest of the bar and in the channel across it varied from time to time.

In 1828 and in 1845 the crest of the bar was above water for most of the distance across the bay, the channel (at the same place as the present one) being stated in the annual report for 1847 "to have but 2 feet of water." If this meant the actual depth, which seems probable, its reduction to extreme low-water level would give but half a foot.

In 1853, just before the first jetty construction, the depth was 1¼ feet below extreme lowwater, which was in 1854 increased by dredging, under the shelter of the west jetty to 6 feet. The amount of material then removed to make the channel, which appears to have been about 450 feet long and 80 feet wide, must have been about 4,000 cubic yards.

In 1866, when the next work of improvement was begun, a detailed survey showed this cut to be 5½ feet deep.

As the west jetty was extended during 1866, 1867, and 1868, the channel was enlarged by dredging close beside the jetty and in August, 1868, it was reported to be 10 feet deep, 80 feet wide, and 800 feet long. The amount dredged is not reported, but it appears to have been about 15,000 cubic yards, at a cost of 24 cents per cubic yard in scows.

In 1869, the width had been increased to 200 feet, but in 1871 22,625 cubic yards of gravel, sand, and mud were excavated, at 17 cents per cubic yard, to make the depth 10 feet over this width for 1,200 feet length from bay to lake.

In 1872 and 1873 small amounts of dredging were done at $1 per cubic yard, but it was limited to the excavation of a trench for crib foundations and no dredging was then done in the channel.

In 1875, a shoal about 100 feet wide had formed across the channel by sand-drift around the outer end of the west jetty, which then extended only to the 9-foot curve. This shoal had 8 feet depth and 1,592 cubic yards were dredged from it at 25 cents per cubic yard, to make a passage 80 feet wide next to the west jetty.

An exceptionally high stage of water prevailed in the lake in 1876, and no further dredging was done until 1879, when the deepening of the channel to 15 feet depth at extreme low water was begun. During 1879 and 1880 and 1881 there were removed 25,931 cubic yards of gravel, sand, and mud, at 18 cents per cubic yard, scow measurement, and the work was continued in 1881 at 17¾ cents per yard. At the latter rate, 43,562 cubic yards, scow measure, were removed up to December 1, 1881, making 15 feet depth at extreme low water for 200 feet width and 1,700 feet length.

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This carried the excavation out as far as the west jetty then extended, 242 feet beyond the light-house pier head. The jetty was extended 472 feet farther in 1883 and 1885, but no attempt was made to extend the excavated channel, as the fact was developed that the material composing the remainder of the bar was a tough hard pan, instead of gravel and sand as the rest had been, and money for its removal was not available, 20,000 cubic yards being the excavation required to make 15 feet depth, the estimated cost being $1 per cubic yard.

In 1891 the space between the jetties had gradually shoaled to about 12 feet by the deposit of loose sand and mud.

The new United States dredge *Frontenac* began work on October 9, 1891, continuing until December 1, when weather permitted. During this time 7,257 cubic yards of sand and mud and 541 cubic yards of hardpan were removed. The work done showed that the hardpan is too tough to be dredged economically and that blasting will be necessary for its removal.

OPERATIONS.

The work of removing the superstructure of 800 feet of the East Breakwater, being all of Section C, and the western 50 feet of Section B, was begun August 10, 1891, and continued until December 21, 1891, when it was practically completed. There remains only a small amount of smoothing up and finishing now to be done. This work indeed is not necessary to the strength and durability of the work, but is mainly to give it a neat and workmanlike appearance.

The superstructure was built in the parapet form, according to the most recent and approved design. The lumber and iron required for the work were purchased by public notice and sealed proposals; the other material and labor required were obtained in open market. This is an excellent piece of work, and is well and economically done. Its cost was $7,594.85, divided as follows:

Labor	$3,047.41
Lumber	3,449.96
Iron	559.10
Stone	498.98
Other material and tools	39,40
Total	7,594.85

Or at the rate of $9.49½ per foot. This sum includes the cost of an unusually large amount of stone, which it was necessary to purchase in order to fill the superstructure on account of its increased height.

Under authority of the Chief of Engineers $5,000 was expended from the appropriation for this work towards the purchase of a dredging plant for use in the harbors in this district.

The plant was built at Oswego, N. Y., and was completed and ready for use early in October, 1891. On the 9th of October the plant was sent to Little Sodus Bay, for use in deepening the jetty channel. The governing depth then was 12 feet at low water, and it was intended to deepen it to 15 feet. The material to be removed, as stated elsewhere, was a very hard and tough hardpan. The dredge could dig it, but the rate of progress was slow; and the severe strain that it was necessary to put upon the machinery caused many small breakages. The experiment showed that it would be more economical to break up the material by blasting before attempting to remove it.

No suitable drilling plant was available last fall, so this method was

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not employed at that time. The dredge continued to work when the condition of the lake permitted until the end of November, when it returned to Oswego and was laid up for the winter.

The total material dredged and removed from the channel was as follows:

	Cubic yards.
Hardpan	541
Sand	7,257

The amount expended for this purpose was $2,622.29, the cost being reasonable considering the character of the material. In addition to the foregoing sums, $1,001.52 has been expended during the fiscal year for engineering and office expenses.

REMARKS.

The reports show a small increase in the number of vessels arriving at this harbor over that of last year; but no material increase can be looked for till the effective depth of the channel is increased.

The completion of the project requires about 665 feet of pier extension, and the dredging of 20,000 cubic yards of hard material from the channel. This will cost in all about $58,500, and in addition to this sum there should be available $6,000 every year for the repair and maintenance of the existing works. The material to be dredged through from the outer end of the jetties to the 15-foot curve in the lake appears to be all hardpan, and it is reasonable to expect that a cut dredged through it would remain open, unless filled up by sand moved out beyond the ends of the jetties from the beach.

There is no satisfactory evidence that the beach sand is moved out as far as this. Even if the sand does move out to the location of the cut in moderate quantities it might be cheaper to maintain the channel by dredging than it would be to keep the increased length of jetties in repair.

I think the experiment worth trying at this place, and I would, therefore, recommend that the jetties be not extended any farther until after the proposed dredging has been completed and the effect observed for one or two seasons.

The small amount of money now available will be applied during the present season to dredging and blasting in the channel according to the project.

Name of harbor, Little Sodus Bay, New York. Collection district, Oswego, N. Y. Nearest light-house, Fair Haven, N. Y.; a fixed white light of the fourth order near the head of the west pier, a fog bell attached; a mast range light at inner end of west pier. Nearest work of defense, Fort Ontario, N. Y.

Money statement.

July 1, 1891, balance unexpended	$17,960.52
June 30, 1892, amount expended during fiscal year	16,218.66
July 1, 1892, balance unexpended	1,741.86
Amount appropriated by act approved July 13, 1892	6,000.00
Amount available for fiscal year ending June 30, 1893	7,741.86
Amount (estimated) required for completion of existing project	52,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	40,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Little Sodus Harbor, New York, during fiscal year ending June 30, 1893.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	57	2,673	51	8,017	46	11,168
Foreign, on lake	27	3,832	158	33,470	62	22,590
Total	84	6,505	209	41,487	108	33,758
American owned	58	2,728	28	1,537	36	8,596
Canadian owned	26	3,777	181	39,950	72	25,162

Sum total, 401 arrivals; registered tonnage, 81.750.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	59	2,707	26	2,565	30	8,024
Foreign, on lake	25	3,798	182	38,770	78	25,734
Total	84	6,505	208	41,335	108	33,758

Sum total, 400 departures; registered tonnage, 81,598.

Greatest draft of vessels, 13 feet.
Greatest tonnage, 585 registered tons.
Greatest load, 1,193 net tons of coal.

Receipts and shipments by lake at Little Sodus Harbor, New York, during the fiscal year ending June 30, 1892.

Trade.	Receipts.						Shipments.		
	Passengers.	Grain.	Fish,	Railroad ties.	Posts.	Lumber, etc.	Passengers.	Merchandise.	Coal.
	No.	*Net tons.*	*Net tons.*	*Tons.*	*Tons.*	*Tons.*	*No.*	*Net tons.*	*Net tons.*
Home, on lake	512	.....	.....	.....	.....	.....	492	8	7,250
Foreign, on lake	.....	235	12	3,746	567	279	....	.....	122,144
Total	512	235	12	3,746	567	279	492	8	129,394

Navigation closed December 14, 1891.
Navigation opened April 8, 1892.

For the purpose of reduction to tons weight the following is assumed: Barrels oil, 7 equal 1 ton; M lumber, 1 equal 1½ tons; crates fruit, 20 equal 1 ton; railroad ties, 12 equal 1 ton; cords wood and posts, 1 equal 1½ tons; live animals, 4 equal 1 ton.

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O O 5.

IMPROVEMENT OF HARBOR AT OSWEGO, NEW YORK.

OBJECT.

To provide a basin sufficient for the needs of commerce at the mouth of the Oswego River, New York, on Lake Ontario, and to secure and maintain a navigable channel into said basin and river.

PROJECT.

1827.—To inclose by breakwaters a western basin of 11 acres area outside the bulkhead line, and an eastern basin of 9 acres outside the bulkhead line, and to protect the entrance channel by piers. (Completed 1829; pier extended 1869).

1870.—To inclose by a breakwater of crib work filled with stone a western basin of 100 acres area outside the 9-foot curve and the existing western breakwater. (Completed in 1882.)

1882.—To build an eastern breakwater on the alignment of the western, sheltering an eastern basin. (Superseded by project of 1888.)

1883.—To build spurs projecting from lake face of western breakwater for the purpose of breaking the accumulated and reflex waves occasioned by that breakwater, which have rendered the entrance exceptionally difficult and dangerous during storm. (Completed in 1889.)

1888.—To remove the east breakwater. (Removed in 1889.)

1891.—To make permanent and to shelter the western entrance to the outer harbor.

PRESENT WORKS.

(1) The present works consist of the inner west breakwater, which lies wholly within the outer breakwater, by which it has been superseded.

(2) The inner east breakwater, which has been private property since 1852.

(3) The Fort Wharf, which constitutes a storage place for harbor material.

(4) The outer west breakwater, whose maintenance constitutes the principal work.

(5) The detached spurs outside the outer breakwater, two of which have been built, and of which two more are proposed to shelter the present western opening.

(6) The deepening of the entrance and river channel in the inner harbor. These works are described in detail as follows:

(1) *The inner west breakwater.*—This is 1,993 feet long, of masony and crib work of varying widths, and was built between 1827 and 1837. The original structure was composed of cribs of timber, each 30 feet wide and 30 feet long, sunk end to end upon the natural lake bottom in as close contact as was practicable by filling with loose stone.

The cribs were formed of round logs, hewn flat, framed together and bolted with iron drift bolts and wooden treenails. They had floors of slabs, and were allowed to settle upon the natural bottom for a part of the season before building upon them the continuous superstructure of hewn timber.

The natural depths in which the cribs were placed increased gradu-

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ally from nothing, at the origin of the shore arm on the west side of the mouth of the river, to about 21 feet (at extreme low-water level) at the pier head next the river channel. The construction of the timber breakwater was completed in 1829.

In 1837 the construction of a masonry superstructure of cut limestone was begun at the shore end. This masonry superstructure was built upon the shore arm, and extended for 90 feet along the lake arm during 1837, and 1838, and 1839. This portion still stands, the shore arm being in a fair state of preservation. The masonry was extended 155 feet farther along the cribs of the lake arm in 1845.

This portion was not completed and has gradually been destroyed, the great cost and the unsatisfactory character of foundation afforded by the crib work apparently accounting for its not being completed and extended. This is the only masonry superstructure which has ever been constructed at Oswego Harbor.

Between 1830 and 1837 large sums were expended in attempting to form, in front of the lake arm of the breakwater, a mole of pierre perdue. A mass of loose stone from 100 to 500 pounds each was deposited in front of the crib work, extending 6 feet above water, and along the whole lake front, about 1,100 feet.

In 1834 it was given a regular profile and was paved with massive blocks of Chaumont limestone, 2 feet thick, weighing 3 tons each.

This pavement was 30 feet wide from the face of the breakwater and the foot of the slope was formed of larger blocks, each 10 feet long, 3 feet wide, and 2 feet thick. The waves moved these stones so freely and destroyed the mole so thoroughly that its maintenance was abandoned in 1837.

During low water in 1891, about 150 of these blocks were recovered and piled on the fort wharf for use in repairs of the outer breakwater.

Section A: The shore arm is 250 feet long, 30 feet wide, and has a crib-work base with cut limestone superstructure in parapet form. Built in 1828 with superstructure reconstructed of masonry in 1837–1838. In fair preservation.

Section B, from the angle eastward, 110 feet. The same description as the last except that its condition is ruinous.

Section C, located back of section B, overlapping it and extending past it a distance of 138.8 feet, including a 10-foot passage for boats cut through its east end in 1884.

This section is of crib work, 22 feet wide, built back of the ruined masonry structure in 1854. Its superstructure was rebuilt on its south or harbor face in 1887 and on its lake face in 1891.

It serves to shelter the United States reservation slip, where the United States boats, scows, and dredge are moored, and to provide a storage place for timber needed for repairs.

Section D: This is 838. 2 feet long, in prolongation of the line of the masonry portion of the lake arm eastward, and extends to the lighthouse pier head. It was built in 1828–'29 and its superstructure was rebuilt and repaired in 1844, 1854, 1860, 1867, 1874, and was burned in the great fire of 1881.

It was transferred to the Light-House Department in 1886 and was rebuilt by the Light-House Department in 1889, in parapet form. The superstructure is built of 12 by 12 inch pine timber, filled with loose stone, and decked with 3-inch pine plank. It is 27 feet wide, founded upon the original crib work 30 feet wide.

At the west end of this section, a small crib-work jetty has just been built in 1892, 12 feet wide and 48 feet long, to shelter the passage way

for boats from the outer to the inner harbor. The jetty is formed of a piece of parapet and of old timbers from the 1884 breach in the outer breakwater, and its superstructure is of blocks of stone taken from the adjoining lake bottom.

A bridge crosses the passage way high enough to permit the passage of the Life-Saving Service boat at extreme high water.

Section E is the light-house pier head of irregular form, extending 92 feet on prolongation of the line of the breakwater and 132 feet at a right angle to it northward. Upon a mass of loose stone, inclosed by the cribs forming the pier-head substructure, stands the masonry light-house, which was built in 1836.

The cribs were built in 1835 and its superstructure was repaired and rebuilt repeatedly until the transfer to the Light-House Department in 1886, by which department it was last repaired in 1889.

Section F is 432 feet long, in prolongation northward into the lake of the pier head, and is 30 feet wide. It was not included in the transfer to the Light-House Department. It was built in 1869 of cribs 30 feet long and 30 feet wide, which varied in depth from 15 to 26 feet. These were built of 12 by 12 inch sawed hemlock timber, with floors of 3-inch hemlock plank laid, with 7-inch spaces, upon the screw-bolted timbers of the grillage which formed the bottom of each crib, the floor-plank being 18 inches above the bottom.

The cribs were sunk upon the natural bottom, without dredging or riprap, in depths varying from 11 feet at the pier head to 15 feet at the outer end.

The material forming the bottom was sand and the cribs settled very irregularly into it 4 to 10 feet, making a crooked line and requiring much leveling.

The superstructure of 6 courses of 12 by 12 inch pine, with 3-inch pine deck-plank laid cross-wise 3 inches apart, was completed in 1870 and has not since been renewed. It is thoroughly decayed and its renewal, in parapet form, is the next work proposed. Another section, which was a part of the inner west breakwater, but has disappeared, was designed in 1869 and then made a part of the project, but was not built until September and October, 1871. It was a crib 100 feet long, 10 feet wide, and 7 to 11 feet high, placed across the right angle at the junction of the light-house pier head with the breakwater, the inclosed triangular space being filled with about 1,000 cubic yards of loose stone.

Its purpose was to relieve the pier head and the light-house from the shock of the waves caused by west and northwest winds. It was sunk upon the existing bottom, where the depths at extreme low water were from 2½ to 6½ feet. The material which formed the bottom was the remains of the mole (which had long before disappeared) and the accretion of sand which had formed against the breakwater where the original depth was about 20 feet. The crib and its superstructure were completed, with its deck at 4½ feet above extreme low water, and the space behind it was filled with stone to the same level in October, 1871. During the first northwest gale, in November, it rolled over toward the waves (apparently by the material in its front being cut out and by the reflux of waves which rolled over it into the inclosed space) and was entirely destroyed during the same winter. It now has no place in the project.

(2) *The inner east breakwater.*—This is 750 feet long, 30 feet wide, and is located on the prolongation eastward of the line of the inner west breakwater, from whose pier head it is distant 357 feet.

The Oswego River flows between them into the lake.

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From this point the breakwater extends to the east shore, beneath Fort Ontario. It was built in 1828–'29 in the same manner as the west breakwater. It was repaired in 1844, and in 1852 was transferred to Gerrit Smith, esq., whose estate since 1852 has owned and maintained it, building under its shelter wharf property which for many years was very valuable, but which is now not so much used as formerly. In consequence the breakwater has not been properly maintained for some years past and it is now in a damaged state.

The northwest angle was destroyed in 1891 and has not been rebuilt, and the shore arm is in a ruinous state.

(3) *The fort wharf.*—This is the landing in the inner harbor for Fort Ontario, and forms a part of the United States Reservation pertaining to that fortification. It has been of value in connection with the harbor improvement as a storage place for timber and stone and for framing and launching cribs.

It has a water front of about 250 feet with an area of about 100 feet by 200 feet. The crib work forming its water front was built in 1839, when the fort was built; was repaired in 1863, when the fort was reconstructed, and has recently been repaired above line of no decay for use on the harbor work.

It is now in good order.

(4) *Outer west breakwater.*—This is 6,033 feet long, inclosing 100 acres (outside the 9-foot curve) of what was formerly the open lake in front of the city and of the inner harbor. It starts from the lake shore, nearly a mile westward from the river outlet, and extends eastward upon a line generally parallel to the lake front and 1,200 feet from it to a point opposite the entrance to the inner harbor.

The breakwater is formed of timber crib work filled with loose stone, and is 35 feet wide throughout.

Its substructure is formed of cribs each 35 feet long and 35 feet wide, a few of those last built being of double this length. Its superstructure is also timber and is now in parapet form. Its height on the shore arm is 9⅓ feet above extreme low-water level; on the lake arm, 13⅓ feet.

The original survey for the location of this breakwater was made in September, 1869, the plan was approved by the Board of Engineers March 30, 1870, and the work of construction was begun on July 5, 1871. It was completed in July, 1882. Its details are as follows, all of the cribs being built upon essentially the same plan as those of the shore arm next described.

The shore arm is 916⅓ feet long, from a ledge of rock forming the shore, northeastward into the lake to 18 feet depth at extreme low water.

Section A, from the shore 846⅓ feet, was built in 1871–'72 of cribs, each 35 feet long and wide, sunk in contact with each other upon the natural bottom, the cribs being built to fit the irregular ledges of the rock on which most of them were placed. The cribs were formed of 12 by 12 inch hemlock timber, all the sticks being of the same length—35 feet.

The timber forming the grillage bottoms were screw-bolted together. Those forming the sides were driftbolted, course by course, as built up, the sides being held together against the outward thrust of the loose stone filling by the dovetailed heads of the cross-ties and by corner-inclined halvings.

The floors were of 3-inch hemlock plank, laid 3 inches apart, 18 inches above the bottom, upon the timbers of the grillage, a central space 11 feet square being left without plank.

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The continuous superstructure built the same season upon these cribs was formed of 12 by 12 inch pine timber, 7 courses in height, with a horizontal deck 8 feet above extreme low water, of 3-inch pine plank laid crosswise, 3 inches apart, upon 6 by 12 inch pine joists, loose stone of random sizes being filled in to the top of the joists. The planks were fastened by 9 by ½ inch spikes, and by six longitudinal bands of 2 by ½ inch flat iron.

This deck was maintained by annual repairs of varying extent every year from the first until the rebuilding of the superstructure in 1887. It was then built in low-parapet form of the 1887 model, which differed radically from the 1884 model hereafter described.

The 1887 model is a parapet 9⅓ feet high above extreme low water for one-third the width, with the inner two-thirds 5⅓ feet high. Its timbers are held together by screw bolts and vertical oak posts instead of by tie rods. Deck joists are omitted, and the 4-inch pine deck plank are laid longitudinally and tight together upon the top set of cross-ties. It cost no more than the work which it replaced. It has neither needed nor received any repairs whatever since its completion in December, 1887.

Section B is 70 feet long, in prolongation of the last section, to the angle of the lake arm. It was built in 1871–'72, at the same time and in the same manner as the last section. Its superstructure had the same frequent repairs until 1884, when, with the following section, the superstructure was renewed in parapet form of the 1884 model. It has received some repairs during the year 1892, and the superstructure on the exposed face needs repair below water.

Section C of the lake arm is 2,910 feet long from the angle eastward. Points upon the lake arm are described by naming their distance from the angle, measuring along the axis.

It was built in 1872–'77 of cribs, each 35 feet long and wide, of depths varying from 18 to 30 feet. The cribs were sunk upon the natural bottom of the lake, and about 30 of the first ones settled more or less irregularly into the sand. The bottom upon which the rest stood was of stones and gravel, and very little settlement took place, generally about one to two feet on the lake face.

During the winter of 1872–'73 700 linear feet of cribs, from 80 feet from the angle eastward, were left without superstructure to settle until next season. During the winter the three last cribs, from station 671 to 776, each 28 feet deep, were moved off the line by the waves, the last one being thrown ashore. All the cribs left open were damaged and had to have shallow cribs sunk upon the damaged substructures. This was done in 1873, and the superstructure was built over them 8 feet high above extreme low water with a flat deck. This was annually repaired until 1883, when a more serious damage occurred, by which the superstructure was wrecked and the crib tops carried away to 12 feet depth for 105 feet.

In 1884 these crib tops were rebuilt by sinking 12-foot cribs on top of the original bases, and then the entire superstructure for 2,910 feet, including this piece, was renewed. The renewal was in parapet form upon what is described as the 1884 model. The parapet is 13 feet high on the side next the lake for a width of 12 feet. It offered more resistance to the waves, which had formerly rolled over the lower superstructure which it replaced. In October, 1884, immediately after the completion of this parapet the superstructure was shifted inward from a few inches to 3 feet for 140 feet in length from station 475 to 615. The continuous superstructure was not broken apart by this movement,

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but was curved inward in a mass, the whole superstructure with the shallow crib tops, described as built in 1873 and 1883, sliding upon the base cribs. The separation of the substructure could not be remedied, but bulkheads were at once built at the probable points of fracture of the superstructure so as to limit the damage. On December 8, 1884, the waves of an exceptionally severe northwest gale drove 140 feet of the superstructure through into the harbor, with parts of the substructure down to 4 to 9 feet depth, leaving the bulkheads at each side of the break. The waves which made this breach were observed from the shore with a level by the assistant engineer in charge of the harbor. As they approached the breakwater, and before being affected by it, the regular waves, exclusive of the foam crests, varied from 14 to 18 feet above the still-water level within the harbor. The waves which made the break were 19 feet above still-water level, the speed being 34 miles per hour.

The opening thus made through the breakwater caused so marked an improvement in the sanitary condition of the inclosed space within the harbor, and was so convenient an entrance for vessels and tugs, that it has not been rebuilt and will be made a permanent opening.

Since the building of the 1884 parapet upon this section of 2,910 feet it has received damage at many points and has had considerable repair, though much less than required by the original flat superstructure.

The part of the breakwater which is in a condition needing close attention, and which may need radical repairs, is that near the 1884 breach. The actual breach was limited, as above described, to 140 feet, and it has not since extended. But the superstructure was strained and its joints opened for 100 feet farther on each side, and it has only been maintained by closely watching it and by putting in screw bolts and steel plates to check indicated yielding.

The exposed face of all the cribs of the substructure below water from the angle eastward for about 700 feet (including the 140 feet breach) are more or less shaken, and show signs of weakness. For instance, on January 8, 1890, five courses went out from the lake face of the crib next the angle, 5 to 10 feet below water for 23 feet length. This is at 24 to 47 feet eastward from the angle.

Through this submerged opening all the stone filling was washed out down to 10 feet below water, and a large breach would soon have followed.

It was repaired by building within the parapet interior cribs, closely filling the spaces between the ties and filling these cribs while still suspended above water with concrete and lowering them into place as the concrete was formed.

In this way there were formed 3 monoliths, each 8 feet by 10 feet and 20 feet high, which put no strain upon the shaken lake face. This mode of construction had been proven necessary by the complete destruction in the preceding season of similar interior cribs filled with loose stone, which were placed in a similar break just west of the 1884 breach. That break was only securely repaired by filling the space with massive blocks of limestone too large to escape through the opening.

Another submerged break at 2600, made by a gale February 5, 1890, was 10 feet below water and 8 feet long, and permitted the escape of stone filling for 20 feet. It was repaired by vertical posts screw-bolted and backed with massive blocks. The repairs of these two breaks cost $2,633.

The deck plank of the 1884 parapet, and the joists and ties support-

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ing it, were made of creosoted Georgia pine, and these are sound. But the other timbers already show some decay.

Section D is 570 feet long in prolongation of the last section eastward. It was built in 1877–1879 with its cribs placed upon the natural bottom, some being double the usual length, and with a continuous superstructure, which was 8 feet high with a flat deck. The superstructure received repairs at various times, and in 1890–'91 it was renewed in parapet form, in connection with the following section.

The details of this parapet differed entirely from that of 1884, which it joined, and is also different from the 1887 shore-arm model. Like the latter it is tied together by the tensile strength of screw bolts and oak posts, and its deck is of 4-inch pine plank laid tight. But none of its timbers are dovetailed or cut into, all being left square and full size throughout. It is the only work ever built at Oswego in which no timbers were displaced by gales occurring during its incomplete state.

When 600 feet had been finished the incomplete end of it was left open without dock or stone filling through the winter of 1890–'91. There was an absence this winter of the usual ice covering to protect it, and the gales were as severe as ordinary. But construction was resumed in the spring of 1891, and the work was completed without having to replace a single stick. Its evident stability promises a freedom from repairs equal to that of the shore-arm work.

Section E, is 900 feet long in continuation of the lake arm. Its cribs were built in 1880 and differ from all the preceding ones in that they had a foundation prepared by dredging a trench in the natural sand bottom 3 to 6 feet deep and 55 feet wide, and then filling it with random stone. Its superstructure was renewed with that of the last section in 1891. A part by contract and a part by hired labor.

The comparison of cost by the two systems is made in an appended report by United States Assistant Engineer Judson, who designed this form of structure under the direction of Captain Palfrey, Corps of Engineers.

Section F 490 feet long in continuation of the lake arm to the eastern angle. The cribs were built in 1880–1882, and founded upon random stone placed in a trench 3 to 10 feet deep and 55 feet wide. The cribs were about 18 feet deep, and the original superstructure was built eight courses high with a flat deck. In 1884 the parapet superstructure was built upon the other, all of white pine, without the creosote in the deck and supports which was used in section C.

It was damaged by a schooner which was wrecked against the breakwater in 1885, but the shaken timbers held together until 1891, when the injury was repaired in an effective manner by screw-bolting a large steel plate to the face, below water, and filling back of it with grout of clear cement.

This carries the description to the east end of the lake arm, where the channel arm extends southward, inclosing the beacon crib.

Section G, the channel arm, is 246 feet long from the south side of the lake arm, with which it makes about a right angle, and extends inward. It was built in 1882, its cribs being placed upon a foundation of random stone, filling a trench dredged 4 to 10 feet in the natural sand bottom, where the depth of water was 20 feet and the sand 15 or more feet deeper.

The superstructure upon the first 62 feet next the lake arm had originally a flat deck, 6 feet above extreme low water, and the parapet was added in 1882—like that on the preceding section. The inner 184 feet

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has still the flat deck, but its change to parapet form is part of the project.

Its inner angle was cut into 12 feet below water by a barge in 1891, requiring extensive repairs.

The detached spurs.—Under the project of 1883 two or more detached spurs outside of the outer breakwater were provided for. Of these two have been built; one, situated 250 feet west of the eastern end of the breakwater, was built in 1885. The other, situated midway of the length of breakwater, was built in 1889. The first one consists of a single crib 100 feet long, 40 feet wide, and 25 feet deep, with 4-inch close floors, 4 feet above the bottom, and with vertical sides to mean water level. It is placed with its long axis at a right angle to the face of the breakwater and is separated from the latter by a space of 10 feet. The natural bottom at the place was of sand 15 or more feet deep, and a trench was dug for each side and each end of the crib, 10 feet deep and 15 feet wide at bottom, and this trench was filled with random stone. The riprap base thus formed extended 10 feet outside of the crib outline all around. It was leveled at 21 feet below extreme low water, and the crib sunk upon it.

The superstructure was built upon the crib 14 feet high, sloping from the sides to a central top width of 12 feet. The angle at the foot of the slope is covered and joined to the substructure by plates of half-inch tank iron. The crib is formed of one thickness of 12 by 12 inch hemlock timber, with three top courses of oak. The superstructure is of one thickness of 12 by 12 inch pine timber; the whole is drift-bolted, and strengthened with screw-bolted posts. The deck is 6 inches thick, of 6 by 12 inch pine timber laid lengthwise of crib and tight together. The whole is filled with loose stone. The structure has not yet yielded at any point, but its foundation proved to be insufficient. It was undermined by the wave action along the west face, and in 1888 the west side had settled to 7 or 8 feet lower than the east side. It now stands in this position. Large amounts of dredge material, stone, gravel, etc., have been deposited along the west side, filling it up to 10 feet depth, and the structure appears secure from further settlement.

The 10-foot space between the crib and the breakwater, through which violent wave action occurs, has not shown any of the scour which was looked for, and which was to be expected from its extremely exposed location.

The second detached spur, built in 1889, was located 2,600 feet westward of the eastern end of the breakwater, about midway of its length.

It also is placed with its long axis at a right angle to the breakwater face, from which a 10-foot space separates it.

Its length is 150 feet, with a bottom width of 40 feet, a surface width of 26½ feet, and a top width of 14 feet. The sides slope regularly from 5 feet above the bottom to the top of the superstructure. The floor is of 6-inch hemlock, laid tight, 24 inches above the bottom. None of the timbers are framed or dovetailed, but the structure is tied together by screw bolts through vertical oak posts, and through the sides and ties.

The crib and its superstructure were completed within the harbor, except laying the 6-inch tight deck. Its lower twelve courses were calked, and the crib was ballasted with 1,200 tons of stone filling, and towed to position, when it was sunk by admitting water through gate valves.

The valves were at once closed again, so that a gale which occurred immediately after sinking it, and before it could be filled with stone,

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did not displace the crib, the waves keeping the superstructure filled to the top, 12 feet above water level. The natural bottom at the location was of stone and bowlders, so that it was only necessary to level the bed with 2 feet of riprap. The crib has not settled and is in good condition.

The outer east breakwater was located upon the prolongation eastward of the line of the outer west breakwater and 351.75 feet from it, the entrance to the harbor being between them. It was built in 1882 upon the project of that date as the first section of an outer east breakwater, intended to be 2,700 feet or more in length.

It consisted of a lake arm 213 feet long, with a channel arm 35 feet long. Its cribs were like those of the west breakwater, and its superstructure was built in parapet form the same season as the cribs.

Its removal was projected in 1888 and was done in 1889.

HARBOR DREDGING AND RIVER CHANNEL.

1847.—The first dredging of which there is record was done in 1847, when a gravel bar which had formed across the river channel, apparently about 1,000 feet inside the breakwater, was removed at private expense.

1855.—The next was in 1855, when the United States dredge, under direction of the engineer in charge, was engaged in deepening the entrance to the river near the head of the upper island, at the expense of the city.

1861.—This dredge was sold in 1861 for lack of funds to maintain it. No other dredging is reported up to this date and it is not likely that any had been done, as the harbor and its entrance had a general depth in excess of the draft of the lake vessels.

1866–'69.—In 1866 the inner harbor adjoining the west breakwater was too shoal to accommodate the increased draft of vessels to 12 feet, and its dredging was commenced. The quantity and price of excavation is not stated, but $29,451 was thus expended to June 30, 1867, when about $12,000 was estimated as the cost of completing it. The work was continued and finished in 1868 and 1869, 12 feet depth at extreme low-water level being reported in the west inner harbor.

1881.—No further dredging was done until June, 1881, when work under contract was begun for deepening the river channel from the entrance near the light-house to the head of the island at the foot of Schuyler street for a length of 1,426 feet and a width of 125 feet. This deepened to 15 feet below extreme low-water level the west half of the river channel, outward from the south line of Schuyler street, excepting a small area next the upper island wharf, where bed rock prevented dredging below 12 feet. Twenty-three thousand one hundred and ninety-two cubic yards, at 70 cents per yard in scows, were removed in 1881. The material taken out was gravel and stones, with many large pieces of bed rock, brought down by ice from the river bed in the rapids above the city, the thickness of layer worked upon by the dredge varying from 1 to 6 feet. Before beginning work many borings were made in the area to be worked upon to determine whether the channel could be made. Bed rock, with 12 feet depth, was found beneath the loose deposit, extending out 50 feet into the channel from the east and west island wharves, just north of Schuyler street. No attempt was made to remove this.

1883, 1884.—In September, 1883, dredging was resumed to deepen the east half of the channel. This was done at 30 cents per cubic yard, in

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scows and was completed in July, 1884; 34,123 cubic yards were removed. The material consisted of gravel, stone, and rocks, and was dumped upon the prolongation eastward of the line of the east breakwater to serve as a foundation for the proposed eastern extension of that work. The depth which was made increased from 15 feet at the upper end to 17 feet at the lower end to allow for rise and fall of waves.

1883.—In 1883, without cost to the United States, there was also dredged from the inner west harbor 5,000 cubic yards of gravel for wharf filling.

1887.—Up to this time the draft of vessels had been limited to 12 feet by the depth that could pass the Welland Canal, but in 1887 this was increased to 14 feet, and the inner harbor, above the limit of the dredging of 1884, was too shallow, except at a high stage of lake.

1890.—During 1890 and 1891 rock excavation to 16 feet depth was done at private cost to extend the channel above described up to the Marine Elevator (the most northern one on the east side) and to the New York, Ontario and Western Railroad coal trestle, on the upper east island wharf. This at once increased the available depth of the harbor to 16 feet, and large steamers came to use it before the work was fully complete.

1891.—In 1891 the clearing off of loose material from the bed rock was continued by the United States up to the north line of Cayuga street, a farther distance of 900 feet for 240 feet width, leaving undredged 100 feet next the wharves on each side. Over this area the effective depth was increased 2 to 3 feet, the rock shoaling from 15 feet at the north end of the work to 7½ feet at the south end. Sixteen thousand eight hundred and forty-five cubic yards were removed, at 23½ cents in scows. In addition there were many pieces of ledge rock which the dredge could not raise, which were taken out by the United States hired labor with a derrick boat. The aggregate was about 78 cubic yards, costing an average of $7.58 per yard. After completing this the ridges of gravel and stones were leveled off by dragging a bar of railroad iron over the bottom.

1892.—In 1892 the new United States dredge *Frontenac* was employed to remove a ridge of sand 20 to 50 feet wide, which had formed in the outer harbor along the harbor face of the outer breakwater, by the material washed over and through it. This work began at Station 3075, and extended thence westward to Station 1400. The deposit had reduced the original depth of about 17 feet to 10 to 12 feet, and its removal required the dredging of 10,010 cubic yards, including 385 cubic yards of stone crib filling, which was saved. The dredge also reopened, in 1892, the boat passage, which was originally dredged through the inner old breakwater to the outer harbor in 1884.

OPERATIONS.

Work of renewing the superstructure in the parapet form, 1890 model, on the eastern 170 feet of section E, new breakwater, was begun August 1, 1891. This was a continuation of 1,300 feet of similar work which had just been completed under contract. The lumber required for this 170 feet of work was purchased by public notice and sealed proposals; the other material and the labor required were procured in open market. This work was completed October 26, 1891, and work was in all respects equal to the best done by the contractor, and its cost per foot was somewhat less. A report, making an interesting comparison between the cost of this piece of work done by hired labor and the previous

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work done by contract, has been prepared by Assistant Engineer Judson, who was in local charge of the work, and it is transmitted herewith. The report indicates that if the whole work had been done by hired labor a very considerable saving might have been made. The cost of this work, including the cost of bonding into former work, equivalent to 15 feet additional length, was $7,065.35.

Dredging near the mouth of the river by E. J. Hingston, under formal written contract, was begun July 20, 1891, and was continued until August 31, when, finding that he could not complete his contract by September 20, the date upon which it expired, he asked for and was granted an extension of time till November 1, 1891. By authority of the Chief of Engineers he was not required to pay the cost of inspection during this period. A second extension was afterwards granted to November 15, with the usual requirements that the contractor should pay the increased cost to the United States. The work was finally completed November 13, 1891. The object of this work was to clear off the gravel and loose rock that covered the ledge that forms the bed of the river, over an area of about 24,000 square yards, from the north line of Cayuga street northward to connect with dredging that had previously been done.

The actual amount of material removed by the dredge to accomplish this purpose was 16,845¼ cubic yards, at a cost, including the inspection, of $4,291.97. The contract price was 23½ cents a cubic yard. In connection with this work a small party of laborers with a derrick scow and other suitable appliances removed from this area some 127 pieces of stone that were too large for the dredge to handle. The cost of this work was $458.04; $98 was also expended in drilling and blasting certain very large bowlders that could not be removed in any other way.

This makes the total cost of the work done at the mouth of the river $4,848.01. The estimate was $6,000. The effect of this work is to increase the depth of this much used portion of the harbor nearly 2 feet. It is an important, valuable, and, I think, a permanent improvement. The lake face of the old breakwater near the stone pier was repaired by hired labor for a length of 136 feet, the cost being $706.82.

Advantage was taken of the low stage of the water to recover some large blocks of stone from 2 to 4 tons in weight, which had been placed many years ago in the lake in front of the old west breakwater. They are not much needed now, on account of the shelter afforded by the new breakwater. Ninety-five of them were taken out and placed on the Government wharf. They are very useful in repairing breaks in the cribs below the water line.

The cost of this work was $209.25. A bad place in the outer breakwater east of the first spur crib was repaired in December. This weak place was developed by a gale that occurred November 25, but was the result of injuries done to the pier in 1885, when a schooner collided with it and was wrecked against it. The outer half of the timber wall for a width of about 4 feet and a length of about 15 feet had been split off and carried away, and the remaining half of the timber had been greatly weakened. The injury was partly above and partly below water. It was repaired by studding the back of the break with large-headed spikes, which were allowed to project 3 or 4 inches. A steel plate three-eighths inch thick and large enough to cover the entire break was then bolted over it, and the cavity was thoroughly filled with very rich concrete of cement and sand. The cost was $269.32. The approach to the boat slip through the old west pier was deepened by the United States dredge. A new and higher bridge was built over

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the slip, and two small cribs, made of old material, were sunk to prevent the cut from being filled with gravel by the waves moved by the north east gales, to which it is somewhat exposed. The aggregate length of the two cribs is 48 feet. The superstructure is built of large stone. The cost of this work, not including the dredging, was $679.04.

The United States dredging plant, consisting of one Osgood dipper dredge and two dump scows of 160 cubic yards capacity each, was in process of construction at Oswego, N. Y., at the date of my last annual report. It was completed in October, 1891, and sent to Little Sodus Bay to be used in deepening the jetties channel. This plant by authority of the Chief of Engineers was paid for from the appropriations for several different harbors in this district, the allotment from the appropriation for improving the harbor at Oswego, N. Y., being $3,000. The plant is cared for at Oswego when not in use, and is accounted for in the Oswego returns. The plant returned from Little Sodus Bay at the end of November and was laid up for the winter. In the spring of 1892, after some minor repairs and repainting, the dredge began the work of removing a ridge of sand that had formed against the new breakwater on the harbor side, reducing the available depth from 18 or 20 feet to 10 or 12 feet, and preventing deep-draft vessels from tying up to the breakwater, as it is intended they should. This sand had been carried over the breakwater by waves from the lake, before it was built up in the parapet form. The total amount of sand removed was about 10,000 cubic yards. The dredge also took up and placed upon the breakwater some 385 cubic yards of stone which has been used in repair work. It also assisted in breaking up and destroying a wrecked and sunken crib that was an obstruction in the harbor, and it deepened the approach to the boat slip as before described. The total expended for operating the dredge was $1,660.29. In addition to this, $719.60 worth of stone was purchased for filling a portion of the parapet of the outer breakwater.

Many minor repairs not mentioned above have also been made to the piers and breakwater from time to time as they were required. The aggregate cost of them all was about $700.

The cost of watching and care of all plants and material during the year was $1,226.67. The engineering and office expenses amounted to $2,084.70.

The repair of plant and the purchase of tools and non-expendable material was $931.55.

The sum total of all these amounts somewhat exceeds the total expenditure for the fiscal year. This is due to the difference in the value of material on hand at the beginning and end of the fiscal year.

REMARKS.

The superstructure of the light-house pier extension, which was built in 1869, is very much decayed. It should be renewed as soon as possible and in the parapet form. The parapet should also be extended to the extremity of the channel arm, which extends inward from the eastern end of the lake arm of the breakwater. The space (383.9 feet) between the ends of these two sections forms the entrance to the outer harbor, and as the superstructure of them both is very low, it is difficult to see the ends of them at night, and vessels sometimes strike them in entering and leaving the harbor. If these sections were rebuilt in the parapet form, which is 12 feet high above low water, and the ends toward the channel were painted some color that would show

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best at night, the entrance would be much better and safer. This work will cost about $25,000.

The removal of what had been built of the east breakwater, thus abandoning that portion of the project which called for an eastern basin, leaves the whole in a rather unsatisfactory condition. The entrance to the western basin, which would have been sheltered by the east breakwater, is now exposed to the full force of the northeast gales, and at the same time it is almost impossible for a sailing vessel unaided by steam to enter the west basin at all when driven by a strong wind from the northwest. I am of the opinion that the east breakwater will have to be built either as originally proposed or else in some modified form before the harbor will be entirely safe and satisfactory.

The present project permits the break, 140 feet long in the outer breakwater near the shore arm, to be left open, and proposes the construction of two properly located spur cribs to protect the entrance. The cribs adjacent to the break are considerably shaken and need extensive repairs, and the spur cribs should be built as soon as possible. The whole work will cost about $75,000. In addition to the sums above mentioned there should be available every year about $25,000 to be used for the repair and maintenance of the existing works.

While all of the harbors on Lake Ontario under my charge show a small increase in the number of vessels arriving and departing, no material increase need be looked for under the existing conditions.

The present fleet on the lakes seems ample for the local business, and the existing tolls on the Welland Canal, discriminating as they do against the ports and harbors of the United States, will be sufficient in the future to prevent any considerable growth of commerce between our Ontario ports and those of the upper lakes. The continuation of the tolls on this canal, combined with the removal of the tolls from the New York State canals, has had the effect of building up the Lake Erie ports at the expense of those of Lake Ontario, and has virtually severed Ontario from the chain of lakes. The year that sees a free route opened between the lakes, either by removal of tolls from the Canadian canal or by the construction of a canal by the United States, will show an increase of business at the Lake Ontario ports that will astonish those who are unacquainted with the real value of this route when unhampered by unnatural and most adverse restrictions.

Name of harbor, Oswego, N. Y.; collection district, Oswego, N. Y.; nearest lighthouse, Oswego, N. Y. A fixed white light of the third order at the eastern end of the old west breakwater; a fixed red light of the fourth order on eastern end of the outer west breakwater, a fog bell attached. Nearest works of defense, Fort Ontario, N. Y.

Money statement.

July 1, 1891, balance unexpended	$29,170.51
June 30, 1892, amount expended during fiscal year	23,381.95
July 1, 1892, balance unexpended	5,788.56
July 1, 1892, outstanding liabilities	10.00
July 1, 1892, balance available	5,778.56
Amount appropriated by act approved July 13, 1892	40,000.00
Amount available for fiscal year ending June 30, 1893	45,778.56

Amount (estimated) required for completion of existing project	85,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	85,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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REPORT OF MR. WILLIAM PIERSON JUDSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., June 1, 1892.

SIR: I have the honor to submit herewith a comparative statement of the actual cost, by contract and by hired labor, of work done upon the Oswego outer breakwater during the year 1891:

The works were precisely alike, and therefore offer an opportunity for interesting comparison of actual cost by the different methods.

In each case the work consisted in removing the original timber superstructure of rectangular cross section 5.7 feet high above mean water level and 35 feet wide, which was built in 1879–'80, and replacing it by timber superstructure in parapet form, 3.4 feet high on the harbor side and 11.4 feet high on the lake side, built after the 1890 model, which was designed specially for this work.

This renewal was required upon 1,470 feet of breakwater. Of this, 1,300 feet was done by contract and 170 feet by hired labor. The latter proved to be the cheaper, costing $146 per 100 feet less, although its smaller extent put on it an undue proportion for the cost of overseeing and derrick engine.

To make a more just statement of the cost by hired labor, if 1,300 feet had been thus built, there is taken the actual cost for material, labor, tools, tug hire, etc., for 100 feet, and to this is added the cost for the overseer, the timekeeper, and the engine-runner which were employed on the smaller work, and also the cost of two subforemen who would have been needed in addition for the larger work. All being calculated per 100 feet for the four months needed for building 1,300 feet.

This shows that for 1,300 feet the actual cost by hired labor for all material, labor, overseeing, and tug hire, etc., would be per 100 feet, $3,614. The detailed estimate, dated July 25, 1890, of probable cost by hired labor, per 100 feet, was $3,626. The actual gross cost by contract for 1,300 feet, as stated in last Annual Report, averaged per 100 feet $3,937. This included cost of inspector and of certain extra work of bonding into the adjoining structure at the beginning.

There was, however, at the last end, to permit bonding into the future work, a larger amount omitted, so that the actual total was less than 1,300 feet of complete work, and this reduction was not allowed for in computing the above average.

The following itemized statements show the average cost per 100 feet, based upon the accurate average amounts of each class of the various materials actually used per 100 feet.

Office and engineering expenses are not included in the comparison, because they would be the same in either case.

Actual cost of parapet superstructure per 100 feet, by contract.

Designation.	Amount.	Rate in place.	Itemized cost in place.
Pine for leveling ..... feet, B. M.	4,105	$33.00	$135.46
Pine timber ..... do	58,220	29.00	1,688.38
Pine plank ..... do	13,626	28.00	381.53
Oak timber ..... do	20,094	38.00	763.57
			2,968.94
Driftbolts, for leveling ..... pounds	315	.05	15.75
Driftbolts ..... do	2,524	.02½	63.10
Screw bolts ..... do	11,897	.03¼	380.70
Wood screws ..... do	200	.04	8.00
Spike ..... do	1,176	.03	35.28
			502.83
Mooring cleat		8.00	8.00
Pitch and tallow around head of vertical bolts			10.80
Removing and replacing stone ballast ..... yards	714	60 cents.	428.40
Inspector, ($\frac{4}{5}$ month at $100 per month)			46.15
Total per 100 feet			3,965.12

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Actual cost of parapet superstructure per 100 feet by hired labor.

Designation.	Amount.	Rate of purchase.	Itemized cost.
Pine for leveling ..... feet, B. M.	4,105	$18.90	$77.58
Pine timber ..... do....	58,220	18.90	1,100.36
Pine plank ..... do....	13,626	18.90	257.53
Oak timber ..... do....	20,094	27.65	555.63
			1,991.10
Drift bolts for leveling ..... pounds.	315	.022	6.93
Drift bolts ..... do....	2,524	.022	55.53
Screw bolts ..... do....	11,897	.023	273.63
Wood screws ..... do....	200	.031	6.20
Spikes ..... do....	1,176	.028	28.81
			371.10
Mooring cleat	.....	.....	5.00
Pitch and tallow around heads of vertical bolts	.....	.....	2.80
Tools and repair of tools	.....	.....	31.36
			39.16
Total	.....	.....	2,401.36
Wages of mechanics and laborers, construction and ballasting			803.24
Overseer, subforeman, time-keeper, and engine runner			104.11
Planing and boring timber, and transporting to and from hired machine, including four handlings (could have been cheaper done by hand on the work)			220.29
Tug hire, towing derrick scows			85.07
Total			1,212.71
Cost per 100 feet			3,614.07

Comparison of these results shows that if the 1,300 feet built by contract had been done by hired labor there would have been a saving to the Government of $4,466.

Very respectfully, your obedient servant,

WM. PIERSON JUDSON,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Oswego Harbor, New York, for fiscal year ending June 30, 1892.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.			
					On lake.		On river.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	463	104,914	199	26,236	106	26,169	.....	.....
Home, on river	64	6,240	.....	.....	.....	.....	583	79,299
Foreign, on lake	345	60,374	715	121,608	316	92,120	.....	.....
Totals	872	171,528	914	147,844	422	118,289	583	79,299
American owned	527	111,154	202	27,569	147	33,436	583	79,299
Canadian owned	345	60,374	714	120,275	275	84,853	.....	.....

Sum total, 2,791 arrivals; 516,960 registered tonnage.

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Arrivals and departures of vessels at Oswego Harbor, New York, etc.—Continued.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.			
					On lake.		On river.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	460	104.870	203	27,752	120	29,847	.....	.....
Home. on river	64	6,240	.....	.....	.....	.....	589	79,909
Foreign, on lake	344	60,196	702	118,334	291	87,272	.....	.....
Totals	870	171,306	905	146,086	411	117,119	589	79,909

Sum total, 2,775 departures; 514,420 registered tonnage.

Greatest draft of vessels, 16½ feet.
Greatest tonnage of vessel, 1,552 registered tons.
Greatest load of vessel, 1,624 net tons coal.

Receipts and shipments by lake and river at Oswego, New York, for the fiscal year ending June 30, 1892.

RECEIPTS.

Trade.	Passengers.	Grain.	Coal	Merchandise.	Fish.	Oil.	Lumber, etc.
	No.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Tons.*	*Tons.*
Home on lake	3,921	19,444	1,474	1,931	41	.....	939
Home on river	.....	1,603	4,952	9,763	.....	18	1,656
Foreign on lake	247	48,425	.....	1,722	13	.....	193,693
Total	4,168	69,472	6,426	13,416	54	18	196,288

SHIPMENTS.

Trade.	Passengers.	Grain.	Coal.	Merchandise.	Oil.	Lumber. etc.
	No.	*Net tons.*	*Net tons.*	*Net tons.*	*Tons.*	*Tons.*
Home on lake	7,453	130	135.471	1,754	40	60
Home on river	.....	34,296	3,288	8,605	.....	55,182
Foreign on lake	161	.....	300,211	1,763	18	324
Total	7,614	34,426	438,970	12,122	58	55,566

Navigation closed December 28, 1891; navigation opened April 5, 1892; total revenue collected at port during fiscal year, $267.109.16.

For the purpose of reduction to tons weight the following is assumed: Barrels oil, 7 equal 1 ton: M lumber, 1 equals 1½ tons; crates fruit, 20 equal 1 ton; railroad ties and poles, 12 equal 1 ton; cords wood and posts, 1 equals 1½ tons; live animals, 4 equal 1 ton.

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O O 6.

IMPROVEMENT OF HARBOR AT SACKETTS HARBOR, NEW YORK.

OBJECT.

To deepen the natural harbor formed by Ship House Point over an area of about 15 acres to 12 feet at extreme low water. This project was adopted in 1881. Previous to this, in 1826–'28, $6,000 had been expended for the same purpose.

PRESENT PROJECT.

To limit the excavation to an area of about 6 acres, and to define the entrance and provide a mooring place by building a crib 18 feet square upon the point of the shoal extending into the harbor from the end of Ship House Point.

Also to check shore drift by extending a jetty across the end of Ship House Point from the crib above described to the bay outside the point.

PRESENT WORKS.

A crib 18 feet square has been built, as proposed in the project; a jetty of stake and fascine work, loaded with stone, has been completed for a distance of 164 feet, and about 24,000 cubic yards of material have been dredged from the sheltered area, giving a depth of 12 feet at extreme low water.

OPERATIONS.

None, other than the collection and reporting of commercial statistics

REMARKS.

This harbor is formed by a natural spur of loose rock and gravel about 800 feet in length, extending in an easterly direction from the shore, so as to form a small sheltered bay, and the value of the harbor depends upon the preservation of this natural spur or breakwater.

During the war of 1812 the United States began the construction of a large naval vessel upon this spur. The vessel was never launched, work on it having been stopped by the treaty of peace; but the vessel was cared for for a great many years, and incidentally the site on which it stood was prevented from washing away, due to wave action. A few years ago the vessel was sold and broken up, and since then this spur has not been cared for, and consequently is slowly being destroyed by the seas.

It is not, however, exposed to very heavy waves, and can be protected by a rough wall of blocks of stone of one or more tons in weight built parallel to it and from 50 to 100 feet in advance of it, where the water is about 6 feet deep. This stone can be advantageously obtained from quarries in the neighborhood and it is estimated that it can be put in for about $3 a cubic yard.

Five thousand dollars could advantageously be applied to this purpose and would be sufficient to complete the proposed wall.

No more dredging seems to be necessary at present.

Name of harbor, Sacketts Harbor, N. Y.; collection district, Cape Vincent, N. Y.; nearest light-house, Sacketts Harbor, N. Y.; a fixed white light of the fifth order, on Horse Island, 1½ miles west of town; nearest works of defense, Fort Ontario, N. Y.

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Money statement.

July 1, 1891, balance unexpended	$503.95
June 30, 1892, amount expended during fiscal year	54.69
July 1, 1892, balance unexpended	449.26
Amount (estimated) required for completion of existing protect	5,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Arrivals and departures of vessels at Sacketts Harbor, New York, during fiscal year ending June 30, 1892.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	84	4,617	73	3,327	7	1,284
Foreign, on lake	.....	.....	14	656	.....	.....
Total	84	4,617	87	3,983	7	1,284
American owned	84	4,617	82	3,750	7	1,284
Canadian owned	.....	.....	5	233	.....	.....

Sum total, 178 arrivals; registered tonnage, 9,884.

DEPARTURES.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	No.	Registered tonnage.	No.	Registered tonnage.	No.	Registered tonnage.
Home, on lake	80	4,317	76	3,428	6	1,124
Foreign, on lake	4	300	10	497	.....	.....
Total	84	4,617	86	3,925	6	1,124

Sum total, 176 departures; registered tonnage, 9,666.

Greatest draft of vessels, 11 feet.
Greatest tonnage, 918 reg. tons.
Greatest load, 600 tons net.

Receipts and shipments by lake at Sacketts Harbor, New York, during fiscal year ending June 30, 1892.

Trade.	Receipts.						Shipments.			
	Passengers.	Grain.	Merchandise.	Hay.	Coal.	Lumber.	Passengers.	Merchandise.	Coal.	Lumber.
	No.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Tons.*	*No.*	*Net tons.*	*Net tons.*	*Tons.*
Home on lake	2,057	.....	1,853	613	4,060	168	2,326	361	40	16
Foreign on lake	.....	13	2	.....	.....	930	.....	77	.....	.....
Total	2,057	13	1,855	613	4,060	1,098	2,326	438	40	16

Navigation closed December 7, 1891. Navigation opened April 12, 1892.

For the purpose of reduction to tons weight the following is assumed: Barrels oil, 7 equal 1 ton; M lumber, 1 equal 1½ tons; crates fruit, 20 equal 1 ton; railroad ties and poles, 12 equal 1 ton; cords, wood and posts, 1 equal 1½ tons; live animals, 4 equal 1 ton.

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APPENDIX P P.

IMPROVEMENT OF SHOALS IN ST. LAWRENCE RIVER, AND OGDENSBURG HARBOR, NEW YORK, AND OF RIVERS AND HARBORS ON LAKE CHAMPLAIN, NEW YORK AND VERMONT.

REPORT OF MAJOR M. B. ADAMS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Shoals between Sister Islands and Crossover Light, St. Lawrence River, New York.
2. Ogdensburg Harbor, New York.
3. Breakwater at Rouse Point, Lake Champlain, New York.
4. Great Chazey River, New York.
5. Breakwater at Gordon Landing, Lake Champlain, Vermont.
6. Plattsburg Harbor, New York.
7. Burlington Harbor, Vermont.
8. Otter Creek, Vermont.
9. Ticonderoga River, New York.
10. Narrows of Lake Champlain, New York and Vermont.

UNITED STATES ENGINEER OFFICE,
Burlington, Vt., July 9, 1892.

GENERAL: I have the honor to transmit herewith annual reports for the river and harbor works under my charge during the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

M. B. ADAMS,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

P P 1.

IMPROVEMENT OF SHOALS BETWEEN SISTER ISLANDS AND CROSSOVER LIGHT, ST. LAWRENCE RIVER, NEW YORK.

The project for this improvement resulted from the survey and report made in compliance with a provision in the river and harbor act of August 11, 1888, directing a survey of the shoals between Sister Islands and Crossover Light to be made; it was submitted July 2, 1889, and printed in the Report of the Chief of Engineers, 1889, pages 2463 and 2464.

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The estimate, as below, provides for the removal of three shoals, the first, or lower one, situated a little below the entrance to Blind Bay; the second, or middle one, near Dark Island; the third, or upper one, about 1½ miles above Dark Island, the distance between the lower and upper shoal being about 4 miles.

ESTIMATE.

Removing 162 cubic yards of rock, lower shoal, at $20 per cubic yard	$3,240
Removing 1,830 cubic yards of rock, middle shoal, at $18 per cubic yard	32,940
Removing 85 cubic yards of rock, upper shoal, at $25 per cubic yard	2,125
Contingencies	5,000
Aggregate	43,305

The act of September 19, 1890, appropriated $5,000 for this improvement. Bids were invited November 8, 1890, and opened December 9, 1890, but, owing to informalities in two of the three bids received, the work was readvertised, and bids were again opened January 13, 1891, the contract being then awarded to William James Daly for the removal of the lower and upper shoals at $16 per cubic yard, measured in place.

Work was to have been done during the winter of 1890–'91, but, owing to ice not forming of sufficient thickness to bear the weight of the machinery, etc., to be used in connection with the operations, a delay in the date for the completion of the contract was requested and granted so as to include the winter season of 1891–'92.

It is recommended that this improvement be defined as the St. Lawrence River above Ogdensburg in making further appropriations for it, as bad shoals exist without the limits named in the acts making the appropriations heretofore.

It is expected that work will soon be commenced and that it will be completed on time, August 31, 1892.

Money statement.

July 1, 1891, balance unexpended	$4,909.44
July 1, 1892, balance unexpended	4,909.44
July 1, 1892, amount covered by uncompleted contracts	3,952.00
July 1, 1892, balance available	957.44
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	10,957.44
Amount (estimated) required for completion of existing project	28,305.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	28,305.00

Sumbitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

Nearly the entire commerce of the St. Lawrence River passes over or near these shoals. The nearest light-house, Crossover Light; greatest draft of vessels, 16 feet.

Amount of commerce which passed over the shoals of the St. Lawrence River between Sister Islands and Crossover Light during calender year 1891.

	1890.	1891.
	Tons.	*Tons.*
Tonnage of American vessels in coast trade	566,022	640,000
Tonnage of American vessels in foreign trade	3,200	25,000
Tonnage of foreign vessels in foreign trade	30,544	50,000
Total	599,766	715,000

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The principal items of merchandise carried by this tonnage were:

	1890.	1891.
	Tons.	*Tons.*
Lumber	21,750	44,600
Wheat, oats, and corn	202,384	22,562
Coal	112,182	135,000
Package freight	35,000	53,000
Flour	.....	7,000
Total	371,316	260,162

P P 2.

IMPROVEMENT OF OGDENSBURG HARBOR, NEW YORK.

When operations were commenced at this harbor the channel afforded depths of 5 to 12 feet only, and now there are three channels from deep water in the St. Lawrence River to the nearest docks or wharves, in which water from 15 to 16 feet deep is afforded, and a channel 12 to 15 feet deep has been made along the city front.

The project formed for the improvement by a board of engineer officers in 1868 provided for dredging the channel of the Oswegatchie River below the bridge, deepening the channel along the city front on the St. Lawrence River and across the bar northeast of the light-house, and the construction of a pile pier to prevent the water of the Oswegatchie spreading over the bar or shoal between these channels. The pile pier was only recommended in the event of the water of the Oswegatchie not following the line of the deepened channels after dredging was completed. The dredging provided in the project was completed in 1876, and the piling proved unnecessary; consequently operations were confined to dredging the channels, which were left in good condition.

The harbor was surveyed in 1880 and showed considerable shoaling of the channels during the four years of inactivity between 1876 and 1880, and that it was due to sawdust and other waste products of sawmills which had been thrown into the Oswegatchie River in violation of local regulations forbidding it; that the shoaling amounted to some 40,000 yards and would cost $12,000 for removal. The practice of throwing these waste products into the river has now ceased.

The original project was estimated to cost $175,000; $107,000 had been expended in 1880, leaving $68,000 still due the improvement, owing to the piling not being required.

In 1882 the harbor was recommended to be placed in condition to admit the largest vessels that would be able to pass through the enlarged Welland Canal, at an estimated cost of $76,000, as follows:

Outer bar, 80,000 yards, at 30 cents per yard	$24,000
Rome, Watertown and Ogdensburg Railroad Wharves, 40,000 yards, at 40 cents per yard	16,000
Oswegatchie mouth, 20,000 yards, at 20 cents per yard	4,000
City Front channel, 160,000 yards, at 20 cents per yard	32,000
Total, 300,000 yards	76,000

The above estimate was intended to provide for a depth of 15 feet in the channels and 16 feet over the bar. With the completion of the

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last contract 237,677 cubic yards had been dredged, at a cost of $51,000, leaving 62,323 cubic yards to be dredged, and $25,000 due the improvement under the project of 1882.

In 1889 a new project was formed and approved for the improvement of this harbor, it being found that the scheme of 1882 would be insufficient for the wants of the harbor when fully carried out.

The last project provides depths of 16.5 feet in all the channels, based on 17-foot depths of dredging, at an estimated cost of $158,950, as follows:

290,000 yards, exclusive of hardpan and solid rock, at 25 cents per yard	$72,500
72,000 yards of hardpan and solid rock, mostly hardpan, at $1 per yard	72,000
	144,500
Add 10 per cent for contingencies	14,450
Total	158,950

The act of September 19, 1890, appropriated $42,000 for this improvement. Bids were duly invited and a contract has been made for the removal of 325,000 cubic yards of sand, mud, gravel, etc., at the very favorable price of 11 cents per cubic yard, which has since undergone modification by allowing 22 cents per yard for 50,000 yards of hardpan without changing the total amount to be paid under the contract.

The survey made at the harbor in November, 1890, shows a more favorable condition of things at the mouth of the Oswegatchie River than any other survey has shown. It is found that there will be no solid rock encountered within the limits of the channel, but that all the material to be removed from that locality will be hardpan, with more or less of bowlders embedded therein.

Operations under the last contract have been commenced with two dredges. One hundred and eight thousand four hundred and fifty-five yards of ordinary material and 9,286 yards of hardpan have been removed to date, and it is expected that the contract will be completed on time, November 30, 1892.

It is expected to apply additional funds as appropriated in the completion of the project of 1889, under the contract system.

The accompanying commercial statistics were obtained through the kindness of the collector of customs.

Money statement.

July 1, 1891, balance unexpended		$41,130.80
June 30, 1892, amount expended during fiscal year		13,574.57
July 1, 1892, balance unexpended		27,556.23
July 1, 1892, outstanding liabilities	$2,569.68	
July 1, 1892, amount covered by uncompleted contracts	21,777.03	
		24,346.71
July 1, 1892, balance available		3,209.52
Amount appropriated by act approved July 13, 1892		40,000.00
Amount available for fiscal year ending June 30, 1893		43,209.52
Amount (estimated) required for completion of existing project		76,950.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Name of harbor, Ogdensburg, N. Y.; collection district, Oswegatchie; nearest light-house, Ogdensburg, N. Y.

Tonnage of vessels entered and cleared, foreign ports and coastwise, 1888 to 1891.

Year.	Foreign ports.				Coastwise.	
	American vessels.		Foreign vessels.			
	Entered.	Cleared.	Entered.	Cleared.	Entered.	Cleared.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1888	12,068	10,503	66,759	62,918	180,214	191,790
1889	18,689	8,472	85,064	80,972	227,819	230,317
1890	12,888	10,868	75,517	66,699	278,388	287,634
1891	23,475	17,411	48,955	45,833	324,010	325,494

Merchandise received and shipped, foreign ports.

Articles.	1888.	1889.	1890.	1891.
Received:	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Lumber	76,566	75,815	117,114	127,152
Barley, etc	13,092	3,676	5,278	17,521
Hay	676	625	164	9
Miscellaneous freight	15,000	25,000	15,000	11,051
Shipped:				
Coal	32,053	65,356	100,192	49,962
Cheese	2,685	4,750	2,725	1,224
Oil	4,000	3,440	2,200	1,000
Miscellaneous freight	29,000	59,000	31,109	1,000
Total	96,506	161,847	156,668	208,918

Merchandise received and shipped, coastwise.

Articles.	1888.	1889.	1890.	1891.
Received:	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Lumber	25,612	47,454	38,142	58,084
Grain	145,345	181,101	227,409	221,678
Flour	22,359	12,436	16,791	14,152
Coal	76,991	66,230	112,181	138,638
Miscellaneous freight	25,000	49,000	31,119	1,878
Shipped:				
Coal	2,756	2,310	700	500
Miscellaneous freight	34,807	47,875	47,271	56,000
Total	332,870	406,406	473,613	490,930

	1888.	1889.	1890.	1891.
Total duties collected	$225,570	$219,481	$224,078	$223,454
Total fees collected	2,946	4,490	3,805	2,772
Value of imports	1,957,440	1,628,674	1,618,616	1,729,389
Value of exports	1,689,675	1,970,974	2,105,214	1,764,831

	1890.	1891.
Value of merchandise entered for warehouse and transhipped in bond	$174,558.00	$72,251.00
Value of merchandise entered for transhipment and exports	38,357.00	417,813.00
Amount of duties on the above	74,641.12	176,376.30

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Merchandise received under consular seal from foreign ports.

Articles.	1890.		1891.	
	Packages.	Value.	Packages.	Value.
Tea	129,669	$1,358,244	54,552	$684,291
Curios	203	9,288	758	31,295
Raw silk	6,957	3,941,752	5,693	2,821,789
Silk goods	81	46,646	108	86,564
Straw braid	1,119	25,165	524	32,488
Chinese groceries	3,027	27,202	2,028	16,316
Firecrackers	8,659	34,426	127	713
Copper matte ... pounds	2,419,112	173,428	15,287,364	561,559
Skins			24	20,550
Total		5,616,151		4,255,443

The greatest draft of vessels at Ogdensburg Harbor is 16 feet.

P P 3.

BREAKWATER AT ROUSE POINT, LAKE CHAMPLAIN, NEW YORK.

The project for this improvement was adopted in 1885 and contemplates the construction of a straight breakwater of rubble and large stones, extending from Stony Point in the general direction of the southern point of the 6-foot curve south of Windmill Point until the 18-foot curve is reached, a total distance of about 2,000 feet.

Operations have been carried on in accordance with the original plan and under contracts dated August 22, 1885, October 28, 1886, November 2, 1888, and December 6, 1890. Under the first contract 800 linear feet of breakwater adjoining the shore were built, which was extended 550 and 140 feet, respectively, under the second and third contracts, and was further extended 210 feet under the fourth and last contract. It is found that another extension 125 feet will carry the end of the structure into 18 feet of water, and it is therefore proposed to terminate the breakwater with another extension of 135 feet, or a little beyond the 18-foot curve, but with a total length of 1,835 feet instead of 2,000 feet.

The estimated cost of the breakwater was originally placed at $110,000. There have been four appropriations to date, amounting to $83,500, the last being that of September 19, 1890; and as it is now estimated that $15,000 more will be sufficient to carry the structure out to the 18-foot curve and to close in the outer end, the total cost will be $98,500 when completed and closed at 1,835 feet in length. The good effects of the improvement are apparent along the town front by the comparative calmness of the water at the docks there during southeasterly storms, which formerly caused considerable commotion.

Money statement.

July 1, 1891, balance unexpended	$7,962.53
June 30, 1892, amount expended during fiscal year	7,954.56
July 1, 1892, balance unexpended	7.97
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	15,007.97

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COMMERCIAL STATISTICS.

Name of harbor, Rouse Point, N. Y.; collection district, Champlain; nearest lighthouse, Windmill Point.

Vessels entered and cleared and duties collected.

Year.	Entered.		Cleared.		Duties collected.
	No.	*Tons.*	*No.*	*Tons.*	
1888	1,082	108,517	1,136	100,816	$318,606,77
1889	1,129	112,635	1,170	113,843	340,670.40
1890	963	83,015	940	92,496	361,987.78
1891	977	92,996	863	81,586	323,462.00

	1890.	1891.
Duties collected		
Duties assessed on merchandise entered for warehouse and transportation to other ports	$361,987.78	$323,462.00
Tonnage tax collected	89,815.25	151,225.00
Fees collected	2,137.20	2,142.00
Miscellaneous collections	8,011.95	4,803.00
	17.84	4,170.00
Total collected and assessed	461,970.02	485,802.00

Number of tons shipped and arrived, Rouse Point, New York.

Articles.	1890.		1891.	
	Shipped.	Arrived.	Shipped.	Arrived.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Boards, deals, plank, etc	30,000	56,000	.....	218,750
Other lumber	4,000	8,000	.....	136,000
Coal	52,000	.....	280,000	.....
Miscellaneous articles	3,800	44,333	11,500	60,000

Greatest draft of vessels, 10 feet. The accompanying commercial statistics were obtained through the kindness of the collector of customs.

P P 4.

IMPROVEMENT OF GREAT CHAZY RIVER, NEW YORK.

The project for this improvement was adopted in 1889, after the survey was made in accordance with the river and harbor act of August 11, 1888.

The first estimate for improvement provided for a channel with a least width of 50 feet and a least depth of 6 feet; but, owing to the cost under this scheme, amounting to $34,000, a second plan was considered, which provides for a least depth of 5 feet and a least width of 40 feet; and, on finding that the cost under this plan would be about one-half the former estimate, work was recommended to be done in accordance therewith, and the project was adopted.

The appropriation of $10,000 by act of September 19, 1890, has been consumed (under contract dated February 16, 1891) in dredging

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26,337$\frac{10}{11}$ yards of bowlders, sand, mud, and clay, in a single cut, from the mouth of the river to Champlain village.

Operations were commenced June 22, 1891, and were completed October 5, 1891, consuming the available funds.

The channel produced by the work as above is only a little more than half that provided under the project for the improvement, and must, of course, be very generally widened in order to complete it.

Money statement.

July 1, 1891, balance unexpended	$9,955.59
June 30, 1892, amount expended during fiscal year	9,955.59
Amount appropriated by act approved July 13, 1892	5,000.00
Amount (estimated) required for completion of existing project	3,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	3,000.00
Submitted in compliance with requirements sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

Name, Great Chazy River, New York; collection district, Champlain; nearest lighthouse, Isle La Motte; greatest draft, 6 feet.

Vessels arrived, departed, etc., 1889, 1890, and 1891.

	1889.		1890.		1891.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steam vessels arrived	38	1,520	36	1,210	26	2,600
Canal boats arrived	56	5,432	44	4,562	10	900
Steam vessels departed	38	1,520	36	1,210	26	2,600
Canal boats departed	53	5,136	44	4,562	17	1,900
Cargoes:						
Value of arrivals	$154,500		$155,000		$7,000	
Value of departures	83,500		81,000		29,000	

Number of tons arrived and shipped, 1890 and 1891.

Articles.	1890.		1891.	
	Shipped.	Arrived.	Shipped.	Arrived.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Potatoes	1,000	.....	1,000	.....
Hay	6,000	.....	800	.....
Iron	100	300	.....	100
General merchandise	611	1,652	500	800
Coal	.....	5,000	.....	1,200

P P 5.

BREAKWATER AT GORDON LANDING, LAKE CHAMPLAIN, VERMONT.

The project for this improvement was adopted in 1887 and has for its object the construction of a breakwater, composed of rubble and large

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stones, extending in a straight line from a point 250 feet south of the dock or landing, where the water is about 3 feet deep at lowest stage, to a point on the 16-foot curve and a little north of the line drawn from the dock to Cumberland Head.

At inception the object of the undertaking seems to have been the affording of increased shelter on the west shore of Grand Isle, Lake Champlain, which incidentally has involved the protection of the dock or landing which gives the improvement its name.

An appropriation of $18,750 was made for this work in the act of August 5, 1886; $10,000 was appropriated by act of August 11, 1888, and $6,000 by act of September 19, 1890, for completion.

The original project was modified so as to make the total length of the breakwater 675 instead of 800 feet.

Operations were carried on by contract. The first contract, dated August 1, 1887, comprised the construction of 500 linear feet of breakwater next the shore. Work was commenced August 11, 1887, and was completed August 31, 1889. The second contract was dated December 28, 1888, and comprised an extension to the above shore section, and when completed, September 30, 1889, left 675 linear feet of breakwater completed, with the exception of the large facing stones and core of rubble on 135 feet at its outer end. For completion of the improvement according to the modified project $6,000 was asked for and appropriated by act of September 19, 1890, which has been consumed under contract dated December 26, 1890, with Edwin H. French, of Fulton, N. Y., for the extension and completion of the breakwater at Gordon Landing, Vermont.

Operations under the last contract were commenced July 6, 1891, and closed September 19, 1891, completing the improvement.

Money statement.

July 1, 1891, balance unexpended	$5,956.05
June 30, 1892, amount expended during fiscal year	5,956.05

COMMERCIAL STATISTICS.

Name, Gordon Landing; collection district, Vermont; nearest light-house, Cumberland Head. The proprietor of the landing states that three-fourths of the business of Grand Isle, Vt., is done there, and that 1,500 tons of freight are probably handled each season; also, that large quantities of produce and fruit, as well as stock for the market, pass over the dock at the landing.

Greatest draft of vessels, 8.5 feet.

P P 6.

IMPROVEMENT OF PLATTSBURG HARBOR, NEW YORK.

The original project for the improvement of this harbor was adopted probably in 1836, the date of the first appropriation, and proposed the construction of a breakwater about 1,000 feet east of the steamboat docks.

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There were 1,250 linear feet of breakwater constructed between the years 1836 and 1875, which is now being extended 300 feet farther northward.

The modification of 1870 provided for an extension of the former structure southeastward, the dredging of some shoal areas within the breakwater, and the protection of a portion of the adjacent beach by a revetment.

Operations were confined to necessary repairs and the dredging of limited areas near the steamboat docks after the completion of the project of 1870, until the act of September 19, 1890, made provision for a northward extension to the breakwater, 300 feet, and for very general repairs to the superstructure.

The appropriation of September, 1890, amounted to $32,500, which has been pledged under one contract, covering the renewal of the old timber superstructure by one composed of large facing stones, with rubblestone cone, and an extension of 300 feet to the breakwater, finished on top in the same manner as has just been described. The cross-section of this superstructure is much like that shown in Fig. 6 of the sheet of cross-sections herewith, but the inner and outer slopes were made equal and the timber of the old substructure was cut down only to low-water level, since the line of no decay is a foot or more above low water.

Work is progressing fairly well under the above contract, the extension has been completed, and the work of rebuilding the old superstructure is about half done. The contract does not require completion until November, 1892, and it is confidently expected will be finished on time. The report of a survey at the mouth of Saranac River, Plattsburg, N. Y., that appeared as House Ex. Doc. No. 72, Forty-eighth Congress, second session, comprehending the dredging of 110,000 yards there, would amount to a considerable extension of the limited areas of dredging operations, and therefore may be said to constitute a further modification in the project for this improvement. It is thought that only small amounts of dredging will be required at this harbor for some years, unless the plan for improving the mouth of Saranac River should be undertaken. A more recent report as to this improvement has appeared as House Ex. Doc. No. 22, Fifty-first Congress, second session.

Money statement.

July 1, 1891, balance unexpended		$31,120.25
June 30, 1892, amount expended during fiscal year		15,844.91
July 1, 1892, balance unexpended		15,275.34
July 1, 1892, outstanding liabilities	$4,052.68	
July 1, 1892, amount covered by uncompleted contracts	8,991.32	
		13,044.00
July 1, 1892, balance available		2,231.34

COMMERCIAL STATISTICS.

Name of harbor, Plattsburg, N. Y.; collection district, Champlain; nearest lighthouse, Cumberland Head; two beacon lights on the Plattsburg breakwater.

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Arrivals of vessels.

	1888.		1889.		1890.		1891.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Steam	838	386, 867	861	389, 150	1, 004	559, 531	998	558, 427
Sail	44	3, 715	41	3, 530	46	4, 278	49	4, 427
Canal	800	71, 938	820	73, 829	908	77, 900	936	80, 835
Total	1, 682	462, 520	1, 722	466, 509	1, 956	641, 708	1, 983	643, 689

Departures of vessels.

Steam	838	386, 867	861	389, 150	1, 004	559, 531	998	558, 427
Sail	44	3, 715	43	3. 654	47	4. 376	49	4. 427
Canal	800	71, 988	820	73, 829	908	78, 180	936	80, 835
Total	1, 682	462, 520	1, 724	466, 633	1, 956	642, 086	1, 983	643, 689

Value of goods shipped and arrived.

	1888.	1889.	1890.	1891.
Shipped	$296, 905	$435, 000	$441, 200	$437, 316
Arrived	60, 586	109, 000	113, 460	117, 381

Vessels enrolled at Plattsburg, N. Y., December 31, 1890 and 1891.

1890.

Number	587
Gross tonnage	56, 250
Net tonnage	53, 404

1891.

Number	609
Gross tonnage	58, 550
Net tonnage	55, 610

Number of tons arrived and shipped, Plattsburg Harbor, New York, 1890 and 1891.

Articles.	1890.		1891.	
	Shipped.	Arrived.	Shipped.	Arrived.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Iron ore	13, 500	.....	17, 350	.....
Potatoes	1, 200	.....	1, 200	.....
Hay	600	.....	.....	.....
Coal	.....	16, 000	.....	17, 000
Lumber	.....	600	650	1, 275
General merchandise	400	257	2, 000	1, 500
Iron	.....	.....	2, 500	.....

Greatest draft of vessels, 10 feet.

The above commercial statistics were kindly furnished by the collector of customs.

P P 7.

IMPROVEMENT OF BURLINGTON HARBOR, VERMONT.

The first project for the improvement of this harbor was probably adopted in 1836. Modifications of the original project have been made

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from time to time so as to afford adequate protection to the increasing commercial and shipping interests of the harbor.

In 1874 an extension 2,000 linear feet northward was proposed and carried out; in 1884, the officer then in charge proposed an extension to the southward; and again, in 1886, a plan for further extension at both ends of the breakwater was considered by the Board of Engineers and received its authoritative sanction in regard to distance from shore whenever built and a 200-foot opening recommended at the north end of the existing structure, in prolonging the breakwater in that direction, also received approval.

The rationality of the irregular outline in this breakwater, *i. e.*, its want of rectilinearity from end to end, is found in its gradual development by successive extensions under different administrations, and at distant periods of time, when the immediate and prospective wants of the harbor necessarily presented very different phases. It is now proposed to gradually withdraw the ends of the breakwater, in prolonging it, from water 36 and 39 feet deep into water about 30 feet deep, and then to keep at a distance of about 1,000 feet from the docks in constructing new work, so as to reduce the cost.

The establishment of a harbor line, to limit the extension of docks and wharves out into the harbor, may become necessary to prevent injurious restrictions of the harbor capacity, especially in consideration of the breakwater being only 1,000 feet distant. The construction of 360 feet northward extension to the breakwater, with a stone superstructure, was the last new work at this harbor. This novel construction meets all expectations thus far, and appears to afford a very cheap and durable breakwater; the cost is practically the same as a breakwater with timber superstructure, and since no timber comes above low water, the life of this new structure, as far as one can judge, may be said to be illimitable.

In further explanation of the above form of construction, as well as to show the development of the present approved form of cross section, the accompanying sheet of cross sections of breakwaters on Lake Champlain, New York and Vermont, is appended.

Regarding the respective merits of these several forms, much depends on the circumstances of construction, the cost of materials in the locality, depth of water, force of the wave action, and of the ice floes, etc.; nevertheless, the following remarks are perhaps pertinent from the experience had in this vicinity.

When the water is 16 feet deep or less, and if the seas are not very strong, the form as in Fig. 4 is probably as good as any, but in deeper water this form is too expensive, owing to its great width of base and the amount of rubble stone foundation required. The form as in Fig. 5, and afterwards as in Fig. 6, was in some sense an evolution from the forms as in Figs. 1 and 3, while endeavoring to reduce the cost of construction by going to less depths with the timber work; also for the form as in Fig. 6, which is the best and that approved for this locality, greater durability was attained without increased cost by substituting above water level an all-stone superstructure for the former one of timber and stone.

All things considered, this form of breakwater, as in Fig. 6, and modified slightly by making equal inner and outer slopes, seems to afford greater advantages than any of the others. The large stones of its outer face should weigh 2 tons and upwards, and should be carefully placed as a paving on a slope of 1 on 1 or less, and then its resistance would seem adequate to almost any degree of wave action. But should it require greater strength, the outer slope could be laid in

cement at no great increase of cost. It will be observed that the lower courses of stone are held in place by the top timbers of the cribs, and that any stone in the outer exposed face must be lifted bodily as well as pulled out from among the adjoining stones in order that the waves may make an impression on this structure; and since none of the stones have been thus displaced, though subjected to repeated storms, and from the known cost of construction, it is reasonable to say that it is both very durable and cheap.

The appropriation of September 19, 1890, $20,000, being for repairs, will only be expended as repairs become absolutely necessary, and will, therefore, probably be sufficient for several years. Some 1,625 cubic yards of stone for filling and riprap to the breakwater, and 55,331 feet, B. M., of timber, were purchased under contract, and repairs were made to 1,000 linear feet of the superstructure by hired labor during the year. No new work is regarded as necessary at present, and no additional funds are asked for this harbor.

The accompanying commercial statistics were supplied by the collector of customs in response to the usual request for them.

Money statement.

July 1, 1891, balance unexpended	$19,531.62
June 30, 1892, amount expended during fiscal year	3,771.73
July 1, 1892, balance unexpended	15,759.89
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	129,000.00

COMMERCIAL STATISTICS.

Name of harbor, Burlington, Vt.; nearest light-house, Juniper Island; collection district, Vermont.

Arrivals and departures of vessels in foreign trade.

	1888.		1889.		1890.		1891.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Arrivals	219	28,462	196	25,524	180	23,304	116	15,568
Departures	219	28,462	196	25,524	180	33,304	106	14,324

Arrivals and departures of vessels in coastwise trade.

	1890.		1891.	
	No.	*Tons.*	*No.*	*Tons.*
Arrivals	1,449	588,505	2,057	581,843
Departures	1,440	587,705	2,072	580,826

Merchandise shipped.

Articles.	1890.		1891.	
	Tons.		*Tons.*	
Lumber	4,253	$66,040	5,228	$81,180
General merchandise	33,000	116,000	38,000	140,000
Total	37,253	182,040	43,228	221,180

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Merchandise received.

Articles.	1890.		1891.	
	Tons.		*Tons.*	
Lumber	33,376	$409,505	28,658	$221,029
Lath	1,258	6,411	1,286	6,719
Shingles	620	5,062	382	4,115
Railroad ties			535	2,333
Coal	95,000	380,000	109,800	439,200
General merchandise	75,000	600,000	78,460	630,859
Total	205,254	1,401,578	219,121	1,304,255

Greatest draft of vessels, 10 feet.

P P 8.

IMPROVEMENT OF OTTER CREEK, VERMONT.

The project for this improvement was adopted in 1872, and, as modified in 1882 and 1884, proposes the formation of a channel from Vergennes, Vt., to Lake Champlain, of a navigable width and a least depth of 8 feet. (See Reports of Chief of Engineers, 1872, page 273; 1882, page 712, and 1884, page 2159.)

The appropriation of September 19, 1890, has been consumed, under contract dated January 12, 1891, with Willard Johnson, of Fulton, N. Y., in dredging 20,995 cubic yards from such shoals as formed the worst obstructions. Operations were commenced October 14, and were completed December 4, 1891.

The improvement was originally estimated to cost $58,146. There have been $41,500 appropriated to date, leaving $16,646 still due the improvement under the existing project.

It is believed that $10,000 (to be applied to rock excavation) will be sufficient to carry out the original scheme of improvement; but it is feared that the improvement is not going to prove very permanent when fully completed. It has been found necessary to repeat operations at Bull Brook Bend, after leaving that part of the stream in excellent condition, and there is nothing to give assurance that accretions may not occur on the shoal there again or elsewhere during the season of freshets.

The accompanying commercial statistics were kindly furnished by the collector of customs, district of Vermont.

Money statement.

July 1, 1891, balance unexpended	$4,979.17
June 30, 1892, amount expended during fiscal year	4,979.17
Amount appropriated by act approved July 13, 1892	10,000.00

COMMERCIAL STATISTICS.

Name, Otter Creek, Vermont; nearest light-house, Split Rock; collection district, Vermont; greatest draft of vessels, 7.5 feet,

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Arrivals and departures, 1887, 1890, and 1891.

Kind of craft.	1887.		1890.		1891.	
	Arrived.	Cleared.	Arrived.	Cleared.	Arrived.	Cleared.
Unrigged	112	112	33	33	40	40
Sail					4	4
Steam tugs	168	168	30	30		
Steam-vessels	294	294	185	185	213	207

Total tons of merchandise, in 1879, arrived, 6,350; cleared, 500; 1890, arrived, 3,361; cleared, 370; 1891, arrived, 4,449; cleared, 1,812.

P P 9.

IMPROVEMENT OF TICONDEROGA RIVER, NEW YORK.

The project for this improvement was adopted in 1881, its object being the formation of a channel of navigable width and a least depth of 8 feet at low water between the falls of Ticonderoga and Lake Champlain, a distance of about 2 miles. (See Report of Chief of Engineers, 1881, page 726.)

The improvement was estimated to cost $42,516, of which amount $16,500 have been appropriated and $26,016 are still due the improvement.

The appropriation of September 19, 1890, has been expended, under contract dated January 12, 1891, with Willard Johnson, of Fulton, N. Y., in dredging 8,132 cubic yards from shoal places near the mouth of the river. Operations commenced May 7 and were completed May 21, 1892.

In order to carry out the scheme of improvement the existing channel will require very general widening and deepening, and when this has been accomplished the permanency of the improvement is regarded as extremely questionable. At the rate at which work has been carried on little more than keeping pace with the annual accretions has been accomplished; we may gain a little on the channel in one part only to lose in another part, and thus alternating and remitting of efforts, with the exhaustion of the small appropriations, no permanent gain has been effected. In the prosecution of this work, if it is deemed best to proceed with it, larger appropriations seem to be absolutely necessary for the purpose of generally benefiting the channel.

Money statement.

July 1, 1891, balance unexpended	$1,977.75
June 30, 1892, amount expended during fiscal year	1,977.75
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	26,016.00

COMMERCIAL STATISTICS.

No statistics for 1890 were obtainable, and those for 1881, 1886, and 1891 are appended:

Freight received: 1881, 38,000 tons; 1886, 55,000 tons; 1891, 63,000 tons, and 34,000 tons shipped.

Google

I am informed that the residents of Ticonderoga declare that the work on the river channel keeps down the rate of freight.

Draft of vessels, 6 feet.

P P 10.

IMPROVEMENT OF NARROWS OF LAKE CHAMPLAIN, NEW YORK AND VERMONT.

The original project for this improvement was adopted in 1885, and had for its object the removal of such obstructions in the channel between Whitehall, N. Y., and a point about a mile below, known as the Elbow, as would afford a least depth of 12 feet, with a least width of 150 feet, and the dredging and removal of 170,000 cubic yards from the channel along Cedar Mountain and across Kenyon Bay, so as to afford a least depth of 12 feet and a width of 200 feet.

The entire undertaking was estimated to cost $80,000, the items of the estimate being as follows:

(1) Removal of rock at Elbow, 600 yards, at $5	$3,000
(2) Widening channel at Elbow, 9,000 yards, at 30 cents	2,700
(3) Widening and deepening channel between Whitehall and Elbow, 60,000 yards, at 30 cents	18,000
(4) Widening and deepening channel in Whitehall Harbor, 10,000 yards, at 30 cents	3,000
(5) Widening and deepening channel along Cedar Mountain, 65,000 yards, 25 cents	16,250
(6) Widening and deepening channel across Kenyon Bay, 105,000 yards, at 25 cents	26,250
(7) Closing cross channel, mattresses, etc	500
(8) Moving Beacon XV	1,000
(9) Contingencies	9,300
Total	80,000

There have been two appropriations for this work: August 5, 1886, $30,000, and August 11, 1888, $15,000; total, $45,000.

The rock at Elbow, including considerable loose material around it, and 101,101 cubic yards in Kenyon Bay, were removed at a total cost of $28,638.61, inclusive of contingencies, July 17, 1888, and 60,000 yards between Whitehall and the Elbow, and 40,000 yrads from the channel along Cedar Mountain were removed under the appropriation of August 11, 1888. The contract was completed and closed in September, 1889, 100,669 cubic yards having been dredged and removed. The cross channel, item 7 of the estimate, was closed in connection with the operations along Cedar Mountain; consequently the close of operations in September, 1889, left the original project substantially completed at a little more than half the estimated cost. The difference between the actual and estimated cost was due to the prices for dredging under the contracts, 17 cents per yard under the first, and 10.8 cents under the other, instead of 25 cents and 30 cents per yard as estimated.

A survey from Whitehall to Benson Landing was made in the winter of 1889–'90 to ascertain what improvements are needed on these middle reaches of the narrows of Lake Champlain. The report by Assistant Engineer F. M. Barstow, dated February 28, 1890, was submitted with a letter concurring in the recommendation for improvement under date

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of March 19, 1890. There were 92,000 cubic yards of dredging estimated as required, at a total cost of $21,000, as follows:

South Bay Bend, 60,000 yards, at 20 cents	$12,000
Beacon No. 3 Bend, 12,000 yards, at 25 cents	3,000
Chiltons Bend, 20,000 yards, at 20 cents	4,000
Contingencies	2,000
Total	21,000

The accompanying commercial statistics were obtained through the kindness of the Collector of Customs.

Money statement.

July 1, 1891, balance unexpended	$2,668.87
June 30, 1892, amount expended during fiscal year	378.83
July 1, 1892, balance unexpended	2,290.04
Amount appropriated by act approved July 13, 1892	18,500.00
Amount available for fiscal year ending June 30, 1893	20,790.04

COMMERCIAL STATISTICS.

Number of boats, tows, and tonnage that passed into and out of Whitehall Harbor, New York, during years 1888, 1889, 1890, and 1891.

	1888.	1889.	1890.	1891.
Whole number of tows	475	481	472	448
Average number boats in a tow	15	15	22	14.5
Total boats towed	7,125	7,215	10,384	6,496
Number of tons to a boat	160	150	150	146¼
Total tons carried	1,140,000	1,082,250	1,557,600	731,688
Value of cargoes:				
Arrived	$2,385,000	$2,275,000	$5,750,880	$2,346,250
Departed	2,090,000	2,100,000	3,733,920	1,407,750

Greatest draft of vessels, 10 feet.

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APPENDIX Q Q

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA.

REPORT OF COLONEL G. H. MENDELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 6, 1892.

GENERAL: I have the honor to transmit herewith annual report upon the work of improving harbor at Oakland, Cal., etc., for the year ending June 30, 1892.

Very respectfully, your obedient servant,

G. H. MENDELL,
Colonel, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA.

Operations of the year.—At the beginning of the year five contracts were in force, namely: 1. For delivery and placing stone upon the north jetty. 2. For construction of piers of a highway bridge to span the tidal canal at Park street, Alameda. 3. For a steel highway bridge and draw span at Park street, Alameda. 4. For dredging tidal basin. 5. For dredging the eastern end of the tidal canal.

The first of these contracts, involving 13,367 tons of stone delivered and 61,629 square feet of dry masonry, was fulfilled on October 12, 1891, 9,815 tons of stone having been delivered and 31,528 square feet of masonry having been laid during the year.

The contract for bridge piers was fulfilled on August 20, 1891. The quantity of work done during the year was 600 cubic yards of excavation and 2,351.8 cubic yards of concrete.

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The contract for the highway bridge was practically completed on December 7, 1891, several small items being placed a few days later. The amount of metal in the bridge is 195.2 tons.

Work was begun on the contract to dredge the tidal basin July 1, 1891, and the contract was fulfilled on January 13, 1892. The quantity dredged and securely placed ashore behind levees is 632,905 cubic yards. The distance over which the spoil was transported in pipes varied between 3,000 and 6,000 feet.

At the beginning of the year work had been done under the contract for excavation of the eastern end of the tidal canal to the extent of 250,820 cubic yards dredged and securely placed ashore. No work was done in continuation of this contract until January 26, 1892. The work done during the year, as measured, is 142,088 cubic yards. The agreed date for fulfillment of the contract is June 30, 1892, at which date there remained to be dredged an estimated quantity of 107,000 cubic yards.

Contracts made during the year.—A contract was made on September 28, with the San Francisco Bridge Company, for enlarging the portion of the channel in front of the city of Oakland to a width of 325 feet and depth of 18 feet or less, at low water. The work is to be begun on July 18, 1892. The estimate of work to be done is 125,000 cubic yards. The date set for completion is May 18, 1893.

Present condition of the work.—A survey just made shows that the depths in the channel have been fully maintained. They are practically identical with those found at the close of the last fiscal year. The channel from the Bay of San Francisco to the wharves of Oakland is for almost all the distance 300 feet in width, with a low-water depth of 14 feet, to which the tide adds an average additional of 4 feet, making 18 or more feet available at high tide.

In front of the wharves of Oakland the width of the channel is reduced to 225 feet.

The north jetty is practically completed, with length of 9,203 feet. The terminal mound is as yet, however, in the rough, and is to be laid up in dry masonry.

The length of the south jetty as it stands, is 11,868 feet, of which 2,465 is in an unfinished condition, and the contemplated extension is about 700 feet, making the projected length 12,680 feet.

The excavation of the tidal basin is completed. The amount of excavation made in the tidal canal is 1,002,445 cubic yards. The quantity estimated to complete the canal is 1,503,832 cubic yards.

The work yet required to carry out the project is mainly embraced in the following items, namely: Completion of the canal; bridge at High street, Alameda; extension and completion of the south jetty; dam at mouth of San Leandro Estuary, and dredging interior channels.

Future operations.—It is expected to apply the next appropriation to further excavation of the tidal canal and protection of its banks; to completion of the south jetty, and to dredging channels, both in the lower and upper parts of the harbor.

Appropriations for improving harbor at Oakland, Cal.

June 23, 1874	$100,000	August 2, 1882	$200,000
March 3, 1875	100,000	July 5, 1884	139,600
August 4, 1876	75,000	August 5, 1885	60,000
June 18, 1878	80,000	August 11, 1888	350,000
March 3, 1879	60,000	September 19, 1890	250,000
June 14, 1880	60,000		
March 3, 1881	60,000	Total	1,534,600

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COMMERCIAL STATISTICS.

The following tables, compiled by Mr. Le Conte, show the general business that passed through the jetties each year since the beginning of operations:

Year.	Traffic by steam ferries.				Traffic by vessels.		
	No.	Trips.	Passengers.	Freight.	No.	Register.	Freight.
				Tons.		*Tons.*	*Tons.*
1874	1	600	None	60,000	1,415	70,750	94,300
1878	3	5,000	216,240	129,000	1,085	109,125	211,627
1881	3	8,800	858,352	1,051,788	1,129	129,714	178,448
1882	3	9,400	892,210	1,150,379	1,004	144,004	257,614
1883	3	8,000	974,901	1,142,918	1,031	143,886	215,829
1884	3	8,000	1,553,769	1,202,230	1,156	163,553	255,738
1885	3	6,000	444,142	1,439,134	1,326	200,226	305,437
1886	3	6,000	318,402	1,487,924	1,673	188,974	264,050
1887	3	8,520	210,423	1,654,451	1,224	130,913	231,660
1888	3	8,520	200,000	1,876,635	1,384	162,957	295,932
1889	3	8,600	100,000	1,755,247	1,745	185,358	338,123
1890	3	8,600	100,000	1,925,957	2,153	213,971	393,478
1891	3	8,600	100,000	2,259,086	2,310	232,706	437,923

This year's report shows a growth in traffic in twelve months of 16⅓ per cent, equal to 378,573 tons.

The freight carried by ferry steamers, 2,259,086 tons, represents miscellaneous merchandise, and includes most of the rail traffic of San Francisco.

The remaining traffic is carried on by vessels with registered tonnage varying between 200 and 1,265 tons, drawing 14 to 18 feet, and by fleet, considerable in number, drawing 10 feet or less.

The classification of freight carried otherwise than on ferry steamers is as follows:

	Tons.
Lumber	207,588
Coal	130,677
Agricultural productions	16,614
Building materials	41,200
Miscellaneous, including supplies and productions of manufacturing industries	41,904

Money statement.

July 1, 1891, balance unexpended	$247,266.79
June 30, 1892, amount expended during fiscal year	164,847.49
July 1, 1892, balance unexpended	82,419.30
July 1, 1892, amount covered by uncompleted contracts	63,676.37
July 1, 1892, balance available	18,742.93
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	168,742.93

Amount (estimated) required for completion of existing project	841,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	300,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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Abstract of proposals for dredging channel in front of city of Oakland, Cal., opened at 11 a. m. September 4, 1891, in accordance with advertisement of August 4, 1891.

Names.	Price per cubic yard.	Total price for 125,000 cubic yards.
	Cents.	
San Francisco Bridge Company	31⅝	*$39,218.75
Pacific Coast Dredging and Reclamation Company	46	57,500.00
	50	62,500.00
Von Schmidt & McNee	87½	109,375.00

* Accepted.

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APPENDIX R R.

IMPROVEMENT OF NAPA RIVER, REDWOOD CREEK, AND SAN LUIS OBISPO, WILMINGTON, AND SAN DIEGO HARBORS, CALIFORNIA.

REPORT OF LIEUTENANT-COLONEL W. H. H. BENYAURD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Napa River, California.
2. Redwood Creek, California.
3. San Luis Obispo Harbor, California.
4. Wilmington Harbor, California.
5. San Diego Harbor, California.

EXAMINATION.

6. Deep-water harbor on Pacific Coast between Points Dume and Capistrano, California.

HARBOR LINES.

7. Establishment of harbor lines at San Pedro, Wilmington Harbor, California.
8. Establishment of harbor lines in San Diego Harbor and adjacent waters, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 6, 1892.

GENERAL: I have the honor to transmit herewith reports upon the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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R R 1.

IMPROVEMENT OF NAPA RIVER, CALIFORNIA.

The project under which the improvement of this river has been carried on contemplated the removal of snags and leaning trees and the deepening of the channel over the bars between Vernon Mills and Carrs Bend, in the immediate vicinity of Napa City, so as to give through that stretch at low tide a channel width of 75 feet and a depth of 4 feet. This latter work was to be accomplished by dredging.

At the commencement of the fiscal year dredging was in progress under contract with Thomas H. Williams, jr. Operations were continued until December 11, at which date the contractor completed his work, having dredged during the season 21,972 cubic yards of material, and removed 32 snags.

This work completed the project and left the river in good boating condition. No additional appropriation was recommended last year for this work. Funds will be needed in the future, however, to maintain a good navigable stage of water, as bar formations will occur, due to material brought down from the upper reaches of the river during seasons of freshets.

The total amount appropriated for this work is $17,500, as follows:

Act of August 11, 1888	$7,500
Act of September 19, 1890	10,000

The total amount expended to the close of the fiscal year is $17,458.57.

This work is in the collection district of San Francisco.

Money statement.

July 1, 1891, balance unexpended	$12,219.20
June 30, 1892, amount expended during fiscal year	12,177.77
July 1, 1892, balance unexpended	41.43

COMMERCIAL STATISTICS.

		1884.	1891.
Merchandise, general, received and shipped	tons	22,800	26,108
Coal received	do	5,000	20,588
Hay shipped	do	2,000	3,639
Grain, feed, and flour, received and shipped	do	3,000	7,469
Lumber received	do	18,333	10,125
Wine, received and shipped	do	7,500	18,309
Miscellaneous freight, received and shipped	do	5,936	16,188
Total		64,569	102,318
Steamers		2	3
Tonnage		176	510
Trips by steamers		.....	365

No new lines of transportation have been established during the year.

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R R 2.

IMPROVEMENT OF REDWOOD CREEK, CALIFORNIA.

This work is a continuation of that heretofore carried on under appropriations made for the improvement of Redwood Harbor. The creek was dredged for a length of about 6,000 feet in the vicinity of Redwood City, so as to give a channel 50 feet wide and 3 feet deep at mean low tide. Some time after the completion of this work the dredged channel partially filled up from natural causes. Upon an examination of the channel, and a recommendation of the necessity for further work, an appropriation of $8,000 was made by the river and harbor act of September 19, 1890, to redredge the creek and to widen the channel through the middle ground. This constitutes the present project, and the work is now in progress with the dredge belonging to the improvement of the San Joaquin River. Work was commenced on the 21st of March last, and the channel has been redredged for a distance of 4,660 feet, the total amount of material removed this season being about 40,845 cubic yards.

Work will be continued during the coming year to the extent of the available funds.

There is no expectation that the improvement will be of a permanent character. The channel will gradually fill up again with material brought down from the upper reaches of the creek, and small appropriations will be needed from time to time to maintain a fair navigable condition of the channel. No appropriation is asked for the next fiscal year.

The total amount appropriated for dredging at Redwood is $23,400, as follows:

Redwood Harbor:	
Act of July 5, 1884	$3,000
Act of August 5, 1886	5,000
Act of August 11, 1888	7,400
Redwood Creek:	
Act of September 19, 1890	8,000

The total amount expended, including outstanding liabilities, to the close of the fiscal year is $20,950.92.

This work is in the collection district of San Francisco.

Money statement.

July 1, 1891, balance unexpended	$8,000.00
June 30, 1892, amount expended during fiscal year	5,291.82
July 1, 1892, balance unexpended	2,708.18
July 1, 1892, outstanding liabilities	259.10
July 1, 1892, balance available	2,449.08

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COMMERCIAL STATISTICS.

[Furnished by Hanson & Co.]

Articles.		1887.	1891.
Imports.			
Pine lumber	feet	4,250,000	5,150,000
Redwood lumber	do	1,200,000	4,200,000
Coal	tons	1,500	660
General merchandise	do	4,500	850
Tanners' stock (hides, oils, etc.)	do	4,000	8,995
Exports.			
Redwood lumber	feet	5,000,000	3,000,000
Shingles	number	35,000,000	175,000,000
Split posts	do	425,000	35,000
Firewood	cords	8,000	6,500
Tan bark	do	3,500	.....
Grain	tons	7,000	5,200
Hay	do	8,000	6,700
Tanners' goods (leather, glue stock, etc.)	do	2,000	2,810

	Tons.
Total amount of freight via Redwood Creek, July 1, 1886, to July 1, 1887	60,415
Total amount of freight via Redwood Creek, January 1, 1891, to December 31, 1891	64,499
Increase	4,084

R R 3.

IMPROVEMENT OF SAN LUIS OBISPO HARBOR, CALIFORNIA.

The project for this improvement is to construct a breakwater on Whaler Reef at Port Harford, extending from Point San Luis to Whaler Island and thence to a point where the outer reef rises above high water. The structure is intended to protect the anchorage and landing at Port Harford. Its total length when completed, including the island, will be about 2,300 feet.

That part of the breakwater between Point San Luis and the island, in length about 300 feet, was completed two years ago, and a commencement was made upon the extension beyond the island by depositing rock in the deeper portions of the reef. This latter work has been continued during the past year under a contract with the San Francisco Bridge Company. It was intended to commence as near the island as possible, working thence outward and filling up the low places in the reef to the plane of mean low water as the work progressed. Owing to the almost constant recurrence of a heavy swell over the reef the contractor experienced great difficulty in mooring his vessels in position to deposit the rock properly in place. He had recourse, therefore, to a tramway extending from the island. By this means the breakwater was advanced about 300 feet beyond the island and built above high water throughout that length. To the close of the fiscal year there had been delivered and placed in the above length of structure and in the depressions beyond a total of 7,870.5 tons of rock.

This contract is still in force, and work under it will be completed in

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August. The time of completion has been extended three times, the delays in the work being due partly to causes beyond the control of the contractor, but in a great measure to the imperfect plant with which it was attempted to carry on the work. The latter defect was remedied by a complete change in the outfit for transporting the rock from Morro to the site of the work.

Under permission granted by the Light-House Board the material to fill out the present contract is obtained at Morro Rock, a light-house reservation 20 miles to the northward of Port Harford. This locality is the only one within any reasonable distance where suitable rock for the breakwater can be obtained, and it is considered that we must depend upon that locality entirely for all future supplies of material for the breakwater.

The difficulties attending the passage of loaded barges over Morro Bar and the distance which the material must be transported under conditions of heavy seas and winds necessarily add greatly to the cost of construction. Any small amount appropriated would only deter bidders from seeking the work, except at prices greatly in excess of what it should cost. It is, therefore, desirable in the interests of economy that appropriation be made large enough to justify anyone undertaking the work to provide a suitable plant for the operations.

The amount of $130,000 could be profitably expended in continuing operations during the next fiscal year.

The total amount appropriated for this improvement is $65,000, as follows:

Act of August 11, 1888	$25,000
Act of September 19, 1890	40,000

And the total amount expended, including outstanding liabilities, is $52,053.07.

Money statement.

July 1, 1891, balance unexpended		$39,082.56
June 30, 1892, amount expended during fiscal year		19,435.79
July 1, 1892, balance unexpended		19,646.77
July 1, 1892, outstanding liabilities	$6,699.84	
July 1, 1892, amount covered by uncompleted contracts	11,952.04	
		18,651.88
July 1, 1892, balance available		994.89
Amount appropriated by act approved July 13, 1892		30,000.00
Amount available for fiscal year ending June 30, 1893		30,994.89
Amount (estimated) required for completion of existing project		189,900.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		130,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

	Year the improvement began (1888).		Year ending December 31, 1891.	
	Incoming.	Outgoing.	Incoming.	Outgoing.
Vessels:				
Steam ..... number..	603	603	506	506
Sailing ..... do....	34	34	13	13
Total	637	637	519	519
Tonnage	452,149.34	452,149.34	335,970	335,970
Draft, greatest ..... feet..	18	.....	18	.....
Merchandise, general ..... tons..	8,802	5,669	7,418	1,320.7
Coal ..... do...	2,985	.....	1,211.8	.....
Lumber ..... feet..	8,884,400	.....	2,175.9	.....
Grain ..... tons..	.....	23,305	20.5	22,759.8
Bituminous rock ..... do...	.....	15,342	.....	10,275
Butter ..... do...	.....	.....	.....	1,547.2
Cheese ..... do...	.....	.....	1.2	148.7
Live stock ..... do...	.....	.....	85.5	2,667.4
Hides ..... do...	.....	.....	5.3	.....
Asphaltum ..... do...	.....	.....	.....	184.5
Chrome ore ..... do...	.....	.....	.....	81.4
Onyx ..... do...	.....	.....	.....	41.5

Statistics for both years furnished by the Pacific Coast Railway.

	Tons.
Total amount of freight entered and cleared in 1888	68,425
Total amount of freight entered and cleared in 1891	48,771.6

No new lines of transportation have been established during the year.

R R 4.

IMPROVEMENT OF WILMINGTON HARBOR, CALIFORNIA.

Defore the commencement of this improvement in 1871 there was a depth of less than 2 feet at the entrance to the harbor at mean low tide. The extension of jetties from Rattlesnake Island and Timms Point on the easterly and westerly sides of the harbor respectively, and the dredging of a portion of the interior space, have resulted in giving a depth in the interior channel of not less than 16 feet, and at the entrance of fully 14 feet at the same stage of water. It is expected that future operations will increase this latter depth to 16 feet.

Operations during the past year have consisted in making needed repairs to the east jetty, in raising and extending the west jetty, and in dredging and removing, by blasting, portions of hard material from the inner channel in the vicinity of Deadmans Island.

At the commencement of the fiscal year two contracts for the delivery of stone for the jetties were in force. The total amount of rock delivered during the season of active operations was 21,309 tons. Of this amount 17,763 tons were deposited upon the line of the west jetty, extending that structure a further distance of 800 feet. The remainder, 3,546 tons, was used in strengthening the line of single work of the east jetty at the south end of Rattlesnake Island, where the encroachments of the sea threatened to result in serious damage to the work. The west jetty has now a length of 3,450 feet, and the east jetty, extending to Deadmans Island, has a length of 6,600 feet.

At the close of the dredging operations last year it was found that certain shoal places existed in the channel in the vicinity of Deadmans Island, consisting of material too hard to be removed by the dredging machine. Experiments were therefore made with dynamite, with a view of disintegrating the material and permitting the strong current of the ebb tide to complete the work of removal.

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These operations, conducted at intervals when weather and sea would permit, were entirely successful, and a channel depth of not less than 16 feet at mean low tide can now be carried inside Deadmans Island.

Surveys were made from time to time during the year for a study of the changes taking place in the interior and exterior channels as a result of the operations in progress. The survey made at the close of the fiscal year shows a deepening of the entire channel, giving as a final result a depth at the entrance of fully 14 feet at mean low tide.

The various operations at the locality were in charge of Lieut. James J. Meyler, Corps of Engineers.

The Board of engineer officers appointed to consider the subject of harbor lines, rendered a report under date of July 18, 1891, recommending for adoption certain bulkhead and pier head lines on the easterly and westerly sides of the harbor. The lines as laid out received the approval of the Secretary of War, July 28, 1891.

Any funds made available for the coming fiscal year will be expended in extending the east jetty beyond Deadmans Island, and in keeping in repair the works already constructed. Should the full amount of $51,000, required to complete the present project, be appropriated, no further project will be presented until the results obtained by contemplated jetty extension are fully determined.

The total amount appropriated for this work is $904,000, as follows:

Act of—		Act of—	
March 3, 1871	$200,000	March 3, 1881	$33,000
June 10, 1872	75,000	August 2, 1882	100,000
March 3, 1873	150,000	July 5, 1884	50,000
March 3, 1875	30,000	August 5, 1886	75,000
June 18, 1878	20,000	August 11, 1888	90,000
March 3, 1879	12,000	September 19, 1890	34,000
June 14, 1880	35,000		

The total amount expended to close of the fiscal year, including outstanding liabilities, is $894,450.64.

This work is in the collection district of Los Angeles.

Money statement.

July 1, 1891, balance unexpended	$85,568.18
June 30, 1892, amount expended during fiscal year	75,893.60
July 1, 1892, balance unexpended	9,674.58
July 1, 1892, outstanding liabilities	125.22
July 1, 1892, balance available	9,549.36
Amount appropriated by act approved July 13, 1892	51,000.00
Amount available for fiscal year ending June 30, 1893	60,549.36

COMMERCIAL STATISTICS.

Commercial statistics for the year the improvement began (1871).

	Incoming.	Outgoing.
Vessels:		
Steam	160	160
Sailing	65	65
Total	225	225
Freight ... tons	25,313	9,575
Lumber ... feet	10,938,336	.....

Statistics of commerce for the year ending December 31, 1891.

[Furnished by the collector of customs at Wilmington, Cal.]

	Foreign commerce (outer harbor).		Domestic commerce.	
	Incoming.	Outgoing.	Incoming.	Outgoing.
Vessels:				
Steam	.....	.....	392	392
Sailing	41	35	156	156
Total	41	35	548	548
Tonnage	62,231	53,455	261,455	.....
Draft, greatest ....feet..	28.5	.....	18.5	.....
Merchandise, general....tons..	2,648	1,626	5,250	10,932
Coal ....do....	95,239	.....	.....	.....
Lumber ....feet..	.....	.....	67,151,268	.....

The total amount of revenue collected at the port during the year ending December 31, 1890, was $93,279.77.

The rates upon freight have been reduced since the first expenditure for the improvement of this harbor from $7.50 to 62½ cents per 1,000 feet on lumber and from $5.00 to 75 cents per ton on general merchandise from the outer anchorage.

	Tons.
Total amount of freight entered and cleared in 1871	50,059
Total amount of freight entered and cleared in 1891	208,831
Increase	158,772

One new line of transportation has been established during the year, viz, the Los Angeles Terminal Railway.

R R 5.

IMPROVEMENT OF SAN DIEGO HARBOR, CALIFORNIA.

The present approved project for the improvement of San Diego Harbor contemplates the construction of a jetty on Zuninga Shoals at the entrance of the harbor, keeping in repair the dike built across the mouth of the San Diego River to divert the waters of that stream into False Bay, and maintaining a channel of 24 feet at mean low water through the middle ground.

Jetty.—It is intended to construct a jetty about 7,500 feet in length on Zuninga shoals, extending out from Coronado North Island, with a view of gaining a depth of 26 feet at mean low tide where there is now at same stage scant 21 feet. No work has yet been done. Proceedings were instituted in the United States circuit court for the southern district of California for the purpose of condemning a strip of land, 18.85 acres in extent, on Coronado North Island, needed for jetty purposes. The case was brought to trial about the middle of June, and an award of $13,942.46 was made by the jury for the land in question. Upon possession of the same being obtained by the Government the construction of the jetty will be commenced with the balance of the appropriation of September 19, 1890, combined with any funds appropriated by the bill now being considered in Congress. The work will project from the shore on Coronado North Island about 1,600 feet east of the entrance to the harbor. It will be built of stone deposited upon a brush foundation in the shape of mattresses, both materials being deposited in place from a tramway built from the shore. The structure will first be carried to half tide, with a view of ultimately raising it above high water.

In view of the fact that the auxiliary works, such as the wharf and tramway, needed in connection with the construction are only of a temporary character and will be exposed to the destructive action of the sea and teredo and will therefore need frequent repair and renewal, it is desirable that the work be carried to completion as early as possible. The recommendation made in the report of last year for sufficient funds for carrying on the work is therefore repeated.

Dike.—Previous to the adoption of the present project for the improvement of the entrance to the harbor the only work undertaken by the Government had for its object the prevention of injury to the inner harbor by material brought down the San Diego River in flood stages and deposited in the bay in the vicinity of Old Town.

The object was accomplished by building a strong earthen levee, closing up the mouth of San Diego River, and excavating a new channel leading to False Bay. This work was completed in 1876, and operations since have been simply with a view of keeping the levee in repair.

The work was examined several times during the year and was found to be in good condition and needing no repairs.

Middle Ground.—At the commencement of the year dredging at the head of the middle ground was in progress with an allotment made from the appropriation of September 19, 1890. A channel 250 feet wide and 22 feet deep was completed, enabling the deeper-draft vessels to take a straight channel into the harbor instead of turning Ballast Point. The channel, however, did not maintain its full depth, and it partially shoaled up again. It is not intended to attempt the further improvement of this channel until the jetty construction shall have been extended out sufficiently to cut off the movement of sand over Zuninga Shoals.

A survey of the entire bay, from National City to Ballast Point, in connection with the establishment of harbor lines, was completed October 7, 1891. The report of the Board of Engineer Officers, recommending for adoption certain pier head and bulkhead lines, was forwarded to the Chief of Engineers June 13, 1892. The lines as laid out received the approval of the Secretary of War June 21, 1892.

An appropriation of $200,000 could be profitably expended in jetty construction during the fiscal year ending June 30, 1893.

The total amount appropriated for San Diego Harbor since 1875 is $142,500, as follows:

Act of—	
March 3, 1875	$80,000
March 3, 1879	1,000
August 11, 1888	1,000
September 19, 1890	60,500

and the total amount expended is $91,740.19.

Money statement.

July 1, 1891, balance unexpended	$58,512.16
June 30, 1892, amount expended during fiscal year	7,752.35
July 1, 1892, balance unexpended	50,759.81
Amount appropriated by act approved July 13, 1892	50,000.00
Amount available for fiscal year ending June 30, 1893	100.759.81
Amount (estimated) required for completion of existing project	284,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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COMMERCIAL STATISTICS.

Commercial statistics for the year the improvement began.

	Vessels.	Freight.
	No.	*Tons.*
Entered	201	24,809
Cleared	195	11,647

The vessels (including 109 steamers) had an aggregate tonnage of 122,311 tons.

Commercial statistics for the year ending December 31, 1891.

[Furnished by Mr. A. E. Higgins, special deputy collector.]

	Incoming.	Outgoing.
Vessels:		
Steam ..... No.	296	295
Sailing ..... do.	141	138
Total	437	433
Tonnage	233,869	231,606
Draft, greatest ..... feet	24½	.....
Merchandise, general ..... tons	85,963	.....
Coal ..... do	73,265	.....
Lumber ..... feet	37,044,000	.....
Value of imports	$579,473.82	.....
Value of exports	.....	$552,483.00

Amount of revenue collected at the port during the year ending December 31, 1891, $94,644.61.

Total amount of freight entered and cleared in 1876	tons	36,456
Total amount of freight entered and cleared in 1891	do	210,606
Increase		174,150

One new line of transportation has been established during the year, viz: The Pacific Mail Steamship Company, San Francisco to Panama and intermediate ports.

R R 6.

EXAMINATION FOR DEEP-WATER HARBOR ON THE PACIFIC COAST BETWEEN POINTS DUME AND CAPISTRANO, CALIFORNIA.

[Printed in House Ex. Doc. No. 39, Fifty-second Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 18, 1891.

SIR: I have the honor to submit herewith a copy of report, dated December 8, 1891, of the Board of Engineer Officers constituted under the terms of the river and harbor act approved September 19, 1890, to examine the Pacific coast between Points Dume and Capistrano with a view to determining the best location for a deep-water harbor, together with project and estimates for the work.

The Board after full examination concludes that the selection of a site for a deep-water harbor within the limits designated by the act is

restricted to the harbors in Santa Monica Bay and San Pedro Bay, and is of the opinion that San Pedro is the better of these, and submits alternative estimates of the cost of the necessary breakwaters as follows:

If constructed of rubble and concrete	$4,594,494
If constructed entirely of rubble	*4,126,106

After a careful consideration of the facts in the case as presented by the Board, its views as to the location and general estimates of construction are concurred in by me. The difference in cost of the two breakwaters, for the same arcs of protection, is over $700,000 in favor of San Pedro, and when the other advantages of San Pedro, as detailed by the Board, are taken into consideration, it would seem that its selection has been properly made.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. L. A. GRANT,
Acting Secretary of War.

REPORT OF BOARD OF ENGINEERS ON DEEP HARBOR ON PACIFIC COAST BETWEEN POINTS DUME AND CAPISTRANO, CALIFORNIA.

SAN FRANCISCO, CAL., *December 8, 1891.*

GENERAL: The Board of Engineer Officers appointed under the provisions of the river and harbor act of September 19, 1890, to examine the Pacific coast between Points Dume and Capistrano, with a view of determining the best location for a deep-water harbor, has the honor to submit the following report.†

The section of the act under which the Board was appointed is as follows:

> That the Secretary of War is authorized and directed to appoint a board of three engineer officers of the United States Army, whose duty it shall be to examine the Pacific Coast between Points Dume and Capistrano, with a view to determining the best location for a deep-water harbor. The said board shall report to the Secretary of War a project for said harbor, with the estimated cost of the same, who shall lay said report before Congress at its next session, with the views of the commission and of the Chief of Engineers of the United States Army thereon; and the sum of five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for the purpose.

TOPOGRAPHY.

Points Dume and San Juan Capistrano differ in latitude thirty-five minutes, and in longitude a little more than a degree, and in direct distance they are about 75 miles apart. The general trend of the coast between them is southeast, broken by two bays, Santa Monica Bay, lying between Point Dume and Point Vincente, and San Pedro Bay, lying to the eastward of Point Firmen. The shore between Points Vincente and Firmen is high and rocky, forming the seaward boundary of San Pedro Hill, which rises to the height of 1,475 feet. Passing from Point Dume towards Santa Monica, the foreshore for a distance of 15 miles is abrupt and rocky, being the foothills of the adjacent Cuhuenga mountains.

Proceeding to the eastward, there is a stretch of about 16 miles of foreshore ending at Malaga Cove, which is in greater or less degree practicable in a commercial way.

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*A correction of this amount since the above letter was written makes this estimate $4,137,591.

†Maps accompanying this report not reprinted; printed in House Ex. Doc. No. 39, Fifty-second Congress, first session.

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At and above the village of Santa Monica, the shore is a plateau about 80 feet above the sea, nearly vertical to the sea, covered in front by a sand beach. A depression in the plateau enables a railway to reach the level of a wharf built in front of the town.

About 2 miles to the eastward, low land encircling a lagoon called La Ballona extends for 2 or 3 miles, separated from the ocean by low sand dunes and a fine beach. Thence to Redondo, the foreshore consists of sand dunes, the plateau being retired. Railroads reach the shore both at Ballona and Redondo.

At Malaga Cove a rocky formation having San Pedro Hill close in the background abuts on the ocean, and including Rocky Point, Points Vincente and Firmen, and the intervening ground, extends to the northern end of San Pedro Bay, a distance of 12 miles, quite impracticable for commercial purposes.

Between Point Firmen and Point Lasuen, 16 miles to the eastward, lies San Pedro Bay. In this interval are included Wilmington Harbor, Long Beach, and Anaheim Landing.

The foreshore from Point Firmen to Point Lasuen is practicable throughout its length for commercial uses both upon the plateaus and the lower lands.

Within the limits of San Pedro Bay two lines of railway reach the shore at Wilmington and Long Beach. A short distance beyond Point Lasuen lies Newport Bay, a lagoon which receives the waters of the Santa Ana River. This point has connection by rail with Los Angeles.

To the eastward of Newport Bay the shore again becomes impracticable, and maintains this character to Point San Juan Capistrano, a distance of 15 miles.

It appears from this description that possible commercial sites are topographically limited in Santa Monica Bay to a shore-line length of 16 miles, and in San Pedro Bay and Newport Bay to the same distance of 16 miles. Of the shore line between Points Dume and Capistrano the three impracticable portions, namely, east of Point Dume, about Point Vincente, and between Newport Bay and Capistrano, include 42 miles.

Los Angeles is the metropolis of all adjacent territory, and is the center of all the railroads herein mentioned. It is distant from—

	Miles.		Miles.
Santa Monica	18	San Pedro	22
Ballona	17	Long Beach	22
Redondo	22	Newport	40

A notable characteristic of the shore line of San Pedro Bay and in less degree of Santa Monica Bay is the occurrence of shallow lagoons close to the ocean and separated from it by thin lines of sand beach.

The most important of these lagoons is close under Point Firmen, known now as Wilmington Harbor, it having been improved by the Government. In its natural state it had at the entrance a depth not exceeding 2 feet at low water. It has now 14 feet at that stage. It is hoped, by operations now in progress, to increase the depth by 2 or 3 feet. Vessels drawing 18.6 feet have entered at high water.

The other lagoons in San Pedro Bay are Alamitos and Anaheim. Ballona Lagoon is situated on the shore of Santa Monica Bay.

Reference to these lagoons is made principally in order to state the opinion of the Board to the effect that no one of them is capable of the degree of improvement necessary to make a deep-sea harbor as contemplated by the law.

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HYDROGRAPHY OF SANTA MONICA AND SAN PEDRO BAYS.

Santa Monica Bay.—The hydrography between the village of Santa Monica and Redondo is quite uniform. Just to the westward of Redondo the 10-fathom curve of depth lies about seven-eighths of a mile from the beach, and the interval gradually increases towards Santa Monica, where it becomes 1½ miles. Over all this frontage changes of depth are very gradual. A breakwater of given length placed along any assumed contour of the bed of the bay must on this account shelter a much larger area at Santa Monica than at any other point in Santa Monica Bay. At Redondo a submarine valley heads close to shore, the 10-fathom curve being only about 500 feet distant. Seaward of this point the valley widens and deepens rapidly, reaching a depth of 100 fathoms in 1½ miles. Excessive depth of water makes a breakwater at this point impracticable on account of cost. The practicable locations for a harbor in this bay, topographically possible for a stretch of 16 miles, are limited by the last-named consideration to a line 14 miles in length.

The bay is free from hidden dangers. The bottom is sandy. There is a small area of rocky bottom indicated on the surface by the presence of kelp.

The approach to Santa Monica Bay is free from danger.

San Pedro Bay.—This bay lies shoreward of a line drawn from Point Firmen to Point Lasuen, the direct distance being about 14 miles. The deepest water in the bay is about 15 fathoms. The slope of the bed from the shore seaward is fairly uniform.

Near the mouth of Wilmington Harbor, there is a rock with 3 fathoms over it, having deeper water around it. The presence of kelp indicates rocky bottom about Point Firmen, and in the present anchorage of San Pedro there are also areas of rocky bottom. The eastern end of San Pedro Bay appears to have a sandy bottom.

WINDS, WAVES, AND EXPOSURE.

The prevailing wind on the California coast is from the northwest, nearly parallel to the coast line north of Point Conception, which is in latitude 34° 27′ N. At this point the trend of the coast changes from northwest to west. This fact in connection with the bold topography of the shore causes the prevailing winds along the southerly coast of California to be westerly. This wind never becomes more than a moderate gale. It never produces the heaviest waves. The disturbance of the water due to it is, however, always an inconvenience to vessels lying at a wharf exposed to its action, and when the disturbance is greatest there is danger to vessels. This wind prevails on the southern coast during the greater part of the year with intermission of calms in the autumn and winter. In the last-named season occur the southerly offshore winds, which produce the heaviest waves to which the coast line is exposed.

A northeasterly land wind, known as the "Santa Ana" occasionally blows from the dry hot plains lying to the eastward. Its duration is short, and it is severe, but having no fetch over the sea it raises no waves near shore. It occurs both on Santa Monica and San Pedro bays.

The southeaster comes in the winter and spring, and brings rain. The storm first manifests itself by a wind from the southeast, which continues for a few hours, shifting then to the south and southwest.

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The storm clears up when the wind gets to the northwest. In these storms a heavy sea is developed, which breaks upon the coast line in waves of great magnitude. These waves come from the south and southwest. The waves produced by the southeast wind are short, designated by sailors as choppy. The south and southwest seas, on the other hand, are long and heavy. A vessel at anchor under this exposure must, under these circumstances, get to sea with the possibility of otherwise going ashore. It is the heave of the sea rather than the wind, although the latter alone is sufficiently dangerous, that makes the strongest ground tackle, at times, of no avail.

Although southerly winds prevail during the winter seasons, and bring rain, yet their occurrence in violent form is not frequent, and a season has been known to pass without a severe storm. Nor is the duration of a storm rarely extended over two or three days.

In this respect the conditions of the southern coast of California are much less severe than in higher latitudes. This consideration is of great importance, for the reason that owing to it a lighter profile may be adopted for a breakwater than would be permissible much farther north.

It also happens that a heavy westerly sea sets in unaccompanied by wind due to a cyclonic disturbance in midocean. The propagation shoreward of waves generated at long distance seaward is favored by the unusual depth of the Pacific Ocean.

It appears, then, that Santa Monica Bay is entirely open to the moderate down-coast or west winds, which prevail during the greater part of the year, and that it also is exposed to the dangerous winds and seas which occur during the winter months, coming from the south and southwest. The degree of exposure is, however, not absolutely equal in all parts of the bay. The easterly end, near Malaga Cove, is afforded protection from the winds and seas from the south by the high land to the southward, and which also affords partial protection from the southwest seas. Catalina Island also aids in some degree to shelter this portion of the bay from southerly seas.

On the other hand, Santa Monica Bay is entirely sheltered from the southeast winds by the high lands of San Pedro Hill.

San Pedro Bay is protected by the same high land from the prevailing down-coast wind. In ordinary weather the Bay of San Pedro is quiet and vessels lie safely at anchor, and for the most part discharge cargo with lighters while the wind prevails. It was doubtless this circumstance which made this point the embarcadero of this part of the coast for the Mexican trade before California was acquired by the Americans. In more recent times the greater part of the commerce of this part of the country has also been transacted here. Formerly all the deep-draft vessels from Australia and Puget Sound discharged cargoes in this bay; recently one of these ships discharged at the wharf at Redondo.

San Pedro Bay is also protected to a great extent from the southwest sea and wind by the island of Santa Catalina, which lies about 18 miles offshore to the windward. This island is 17½ miles in length, and its height of 1,500 to 2,000 feet makes its shelter, as far as it extends, complete. It covers 48 degrees of the total arc of exposure from southwest seas, but leaves uncovered the angle between the westerly end of the island and Point Firmen, through which interval the direct southwest swells reach the San Pedro anchorage.

San Pedro Bay is also directly exposed to the southeast seas which approach through the interval between Point San Juan and the east

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erly end of Catalina Island. While the winds and seas from the southeast are not regarded as formidable, those from points farther around to the south that enter through the open space last referred to are considered to be heavier and more violent than those that approach the anchorage ground from the westward of Catalina.

The record of vessels wrecked at San Pedro shows, with one exception, that the disasters occurred during the southerly storms, the heavy sea coming to the eastward of Catalina Island. The vessels were driven ashore on the west line of the bay. Among those lost were the *Nicholas Biddle*, *Callao*, *Adelaide Cooper*, *San Luis*, *American*, *R. P. Buck*, and the *Kennebec*. The exception noted was that of the *Amy*, which was driven ashore at Point Firmen during a northeast storm from the Santa Ana wind gap.

The arc of exposure of Santa Monica, extending from Point Dume on the west to Point Vincente on the east, is 101 degrees, at Ballona 104 degrees, and at Redondo 90 degrees. Leaving out of consideration the last named point, regarded as impracticable on account of depth, we may call the arc of exposure of Santa Monica Bay 102 degrees. From Point Firmen as a center the arc of exposure of San Pedro Bay around to the west end of Catalina Island is 60 degrees. The arc protected by the island is 48 degrees, and the arc included between the easterly end of the island and Point Loma is 42 degrees, making the total exposure of San Pedro Bay to southeast and southwest winds and seas of 102 degrees. The aggregate angle of exposure of the two bays is therefore the same.

In order to secure a deep-water harbor in either bay a breakwater must be constructed in depths of 8 to 10 fathoms, and so located as to cover the interior space over the arcs of exposure. These considerations make the undertaking one of great expense.

In San Pedro Bay the best location for the proposed harbor is at the present anchorage ground on the westerly side of the bay under Point Firmen. The projection of the westerly shore, by which protection is afforded from westerly winds, and from which a breakwater could start, affords advantages over any other section of the bay to the eastward for securing a protected anchorage.

Good holding ground exists at the anchorage. Protection from storms over the open arcs of exposure to the southwest and southeast could be secured by the construction of a breakwater having two arms. Catalina affords protection from southwest seas, as before stated, over an angle of 48 degrees. As indicated on the chart the westerly arm could be started from a point on the shore under Point Firmen, and be extended in a direction south 41 degrees east (magnetic), for a distance of about 2,400 feet, which would carry it beyond a line projected from the middle of the present anchorage ground to the westerly end of Catalina Island. The end of this arm is in 6 fathoms depth. Then leaving a gap of 1,500 feet the easterly arm could be given a direction north 56½ degrees east along the 9½-fathom curve, and be extended about 5,600 feet, which would afford protection from the southeast seas. This arm could be extended easterly, as increased commerce would require more interior space.

There will be some disturbance in the anchorage ground owing to the wide entrance, but not to any serious extent, as the westerly arm and Catalina Island cover the dangerous arc of exposure to the southwest, and the projection of the easterly arm beyond the line of the westerly arm prolonged cuts off the heavier seas from the southeast.

In entering or leaving the anchorage ground sail vessels can take

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the entrance or pass around the end of the easterly arm according to the most favorable conditions of the weather.

In Santa Monica Bay the practical location of a breakwater would be in front of the town of Santa Monica. A structure, located as shown on the chart, and in length about 8,250 feet, would cover an anchorage ground over the angle of exposure between Point Dume and Rocky Point. The westerly 2,000 feet is in water of 7½ to 9 fathoms, the remainder of the structure being in 8 and 9 fathoms.

As at San Pedro, there must be some disturbance in the anchorage ground, due to the approach of waves through the open spaces between the ends of the breakwater and the shore.

In view of the fact that a lighter profile can be adopted at this locality than would suffice for similar structures on the upper coast, two breakwaters are designed, the profiles of which are shown on the drawing herewith. One is built entirely of rubble deposited in place, the other has a rubble base and a concrete superstructure. The former is 20 feet thick on top, 10 feet above high water, with slope in front of 1 on 2½ to a depth of 12 feet below low water. The slope below that depth and in rear is 1 on 1. In the other the rubble rises to a height of 12 feet below low water, at which point it is 20 feet thick with slopes of 1 on 4 for a distance of 21 feet in front, and in rear of 12 feet, the lower slopes being 1 on 1. The concrete superstructure is 20 feet thick and rises to a height of 10 feet above high water.

The estimated cost of these breakwaters is as follows:

Rubble and concrete.

Santa Monica:	
232,222 cubic yards concrete at $15	$3,483,330
991,383 cubic yards rubble at $1.50	1,487,075
	4,970,405
Contingencies, 15 per cent	745,560
	5,715,965
San Pedro:	
157,630 cubic yards concrete at $15	2,364,450
988,082 cubic yards rubble at $1.50	1,482,123
74,320 cubic yards rubble at $2	148,640
	3,995,213
Contingencies, 15 per cent	599,281
	4,594,494

The westerly arm being built entirely of rubble.

All-rubble breakwaters.

Santa Monica:	
282,250 cubic yards at $2	$564,500
2,431,458 cubic yards at $1.50	3,647,187
	4,211,687
Contingencies, 15 per cent	631,753
	4,843,440
San Pedro:	
Westerly arm:	
74,320 cubic yards rubble at $2	148,640
194,355 cubic yards rubble at $1.50	291,532
	440,172

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San Pedro—Continued.

Easterly arm:

194,267 cubic yards rubble at $2	$388,534
1,846,133 cubic yards rubble at $1.50	2,769,200
	3,597,906
Contingencies, 15 per cent	539,685
	4,137,591

Instituting a comparison of the two sites selected, it will be seen that in the aggregate the total arc of exposure is about the same in each, approximating 102°, though the distribution is different in the two bays. Of the total at Santa Monica, 77° included between lines drawn to the westerly end of Catalina Island and Point Dume, are fully exposed to the direct approach of the winds and seas from the west and southwest. The site receives but little protection on the southeast from Catalina Island, distant 36 miles, while the open area between this island and Point Vincente permits the approach of southerly seas that work around the easterly end of the island. To the moderate southwest swell, which is known to prevail the greater part of the year, the site is fully exposed.

San Pedro Bay is sheltered from the westerly winds by Point Firmen. It is open to the winds and seas from the southwest and to the prevailing southwest swell above noted, over an angle of 60° to the westward of Catalina Island. The other arc of exposure of 42° to the eastward of Catalina permits the approach of seas from the southeast, and also those from the south, that double the easterly end of the island.

In its natural condition San Pedro Bay is better protected from the dangerous winds and seas than Santa Monica Bay.

To insure complete protection requires at the former place the construction of two detached breakwaters covering the exposed arcs, the combined length of these structures being about 8,000 feet.

At Santa Monica, a breakwater about 8,250 feet would be required to cover the anchorage ground over the arc between Point Dume and Point Vincente.

As shown by the foregoing estimates, the cost of the breakwater, with the adoption of either type, will be less at San Pedro than at Santa Monica.

The cost of construction for equal lengths of breakwater is in favor of San Pedro on account of the fact that at Santa Monica the breakwater must be located in depths of 7 to 9 fathoms. At San Pedro the westerly arm will be built of rubble in either case, and starting from the shore is extended only to the 6-fathom curve, the easterly arm alone being entirely in the greater depth of 9½ fathoms.

With the commencement of the construction of the westerly arm at San Pedro some protection from westerly swells will immediately be gained.

San Pedro has further advantage in being supplemented by an interior harbor, which is expected, when completed, to afford at mean low tide a depth of 16 feet at the entrance. This can accommodate shipping of 20 feet draft, and will relieve the anchorage ground to that extent. The inner harbor will also be a place of security for the plant during the period of construction.

The material for the breakwater at San Pedro must be brought from Catalina. At Santa Monica it may prove to be possible to obtain sufficient rock from the hills to the northward, but there is at present no satisfactory evidence that such will be the case. If stone shall be

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derived from the shore, it must be deposited from a trestle built to 9 fathoms depth, and exposed to heavy seas. If Catalina has to be depended upon for the supply, the cost of the work will be increased somewhat, as the length of carriage will be double that to San Pedro. The risk attending transportation is also increased.

In view of the fact that San Pedro Bay in its natural condition affords better protection both from prevailing winds and from dangerous storms than Santa Monica Bay; that protection can be secured at less cost for equal development of breakwater at the former than at the latter; that a larger area of protected anchorage from the prevailing westerly swells can be secured, the severe storms from the southeast being infrequent, and that there is already an interior harbor that will be a valuable addition to the outer harbor, the Board considers San Pedro Bay as the better location for the deep-water harbor provided for by the act.

A breakwater with either of the profiles designed will fulfill all conditions of affording a protected anchorage. The cost is in favor of the one built of rubble. As the westerly arm in either case will be of this type and should be built first, the data obtained during its construction will determine the question as to the profile to be adopted for the easterly arm.

Respectfully submitted.

G. H. MENDELL,
Colonel, Corps of Engineers.
G. L. GILLESPIE,
Lieut. Col., Corps of Engineers.
W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

R R 7.

ESTABLISHMENT OF HARBOR LINES AT SAN PEDRO, WILMINGTON HARBOR, CALIFORNIA.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 8, 1892.

GENERAL: The Board of Engineer Officers constituted by Special Orders No. 20, from Headquarters Corps of Engineers, Washington, D. C., March 25, 1891, to consider the subject of harbor lines at San Pedro, Wilmington Harbor, California, rendered a report, under date of July 18, 1891,* recommending for adoption certain pier head and bulkhead lines along the easterly and westerly sides of the harbor. The lines, as laid out and described in the report, received the approval of the Secretary of War.

On the westerly side of the harbor the lines covered the entire front practicable for commercial purposes. On the easterly side the lines were laid out to a limited extent only, covering the front to be occupied by the wharves of the Los Angeles Terminal Railway Company, leaving, as stated in the report, any future extension of these lines to be governed by the commercial necessities of the harbor.

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*See Annual Report, Chief of Engineers, 1891, page 2976.

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The Los Angeles Terminal Railway Company desire to have these lines extended northward in contemplation of the establishment of lumber yards on the southerly end of Rattlesnake Island. The Board therefore recommends for adoption the following described pier head and bulkhead lines on the easterly side of the harbor, forming an extension of those heretofore approved by the Department:

Pier-head line.—Starting from the point last mentioned in the description of the pier-head line in previous report of the Board, which point is on range through northerly end of single work of east jetty and distant therefrom 320 feet; thence in a straight line to a point 805 feet easterly of the northeasterly corner of the San Pedro Lumber Company's wharf, as at present constructed, said distance being measured on a line at right angles to the direction of the main track of the Southern Pacific Railroad on west side of harbor; thence to a point on range through initial point "A" of survey, on Smiths Island, and distant therefrom 1,400 feet.

Bulkhead line.—Starting from the terminal point of the bulkhead line described in previous report of Board, which point is on range through the northerly end of the single work of the east jetty and distant therefrom 30 feet; thence to a point on same range and distant 230 feet from single work; thence parallel to pier-head line to a point on range through the northeasterly corner of the San Pedro Company's wharf; thence to a point on the range through initial point "A" of survey and distant 200 feet from the pier-head line.

As the original map, with the harbor lines previously adopted delineated upon it, is on file in the Department, the lines here recommended and described have been laid out upon a blue print of that map, which is transmitted herewith.*

Respectfully submitted.

G. H. MENDELL,
Colonel, Senior Member.
W. H. H. BENYAURD,
Lieut. Col., Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
August 9, 1892.

Respectfully submitted to the Secretary of War.

The Board of Engineers constituted by Special Orders No. 20, headquarters Corps of Engineers, March 25, 1891, recommend for adoption harbor lines at San Pedro, Wilmington Harbor, California, additional to those established at this locality by the Secretary of War, July 28, 1891 (see Annual Report Chief of Engineers, 1891, page 2976).

It is recommended that the additional lines now proposed be approved, and that the Secretary place his approval both upon the report and the tracing* submitted.

H. M. ADAMS,
Major, Corps of Engineers, in charge.

WAR DEPARTMENT, *August 10, 1892.*

Approved.

L. A. GRANT,
Acting Secretary of War.

*Not printed.

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R R 8.

ESTABLISHMENT OF HARBOR LINES IN SAN DIEGO HARBOR AND ADJACENT WATERS, CALIFORNIA—AT NATIONAL CITY, SAN DIEGO, ROSEVILLE, LA PLAYA, CORONADO, SPANISH BIGHT, AND CORONADO NORTH ISLAND.

SAN FRANCISCO, CAL., *June 13, 1892.*

GENERAL: The Board of Engineer Officers constituted by paragraph 2, Special Orders No. 51, from headquarters Corps of Engineers, October 11, 1888, to establish harbor lines for San Diego Harbor and adjacent waters, rendered a report under date of March 14, 1890, recommending for adoption bulkhead and pier-head lines along portions of the fronts of San Diego and Coronado.* The lines as then laid out received the approval of the Secretary of War. A complete system of lines, as contemplated by the order, was not established, owing to the insufficiency of funds for a survey of the entire bay.

Funds having afterwards been provided and the necessary surveys made, the Board has the honor to recommend for adoption the following described lines for San Diego Harbor and adjacent waters, shown on the accompanying chart.† The lines formerly laid out and adopted form a part of the system here described.

NATIONAL CITY.

Bulkhead line—Beginning at a point on the prolongation of the southerly line of Thirty-first street 1,350 feet southeasterly from the westerly line of Eighth avenue; thence in a straight line to a point on the prolongation of the southerly side of Twenty-fourth street 2,100 feet from the westerly side of Eighth avenue; thence to a point on prolongation of the north side of Nineteenth street 1,600 feet from the westerly side of Eighth avenue; thence to a point on the prolongation of the southerly side of Eleventh street 400 feet from the west line of Eighth avenue; thence to a point on the prolongation of the southerly side of Eighth street 575 feet from the westerly side of Seventh avenue; thence to a point on the prolongation of the southerly line of Fifth street 400 feet from the westerly side of Eighth avenue; thence to a point on the prolongation of the boundary line between National City and San Diego, and distant 400 feet from the westerly side of P avenue in San Diego, measured at right angles to the direction of said P avenue.

SAN DIEGO, ROSEVILLE, AND LA PLAYA.

Beginning at the point last above mentioned, thence in a straight line parallel to P avenue to a line midway between Thor and Una streets prolonged; thence to a point on the prolongation of the southerly side of South Thirty-third street 550 feet from the westerly side of M avenue; thence to a point on the prolongation of the easterly side of Twenty-eighth street 440 feet from the southerly side of Colton avenue; thence to a point on the prolongation of the southeasterly side of South Twenty-eighth street 550 feet from the easterly side of Pierce avenue; thence to a point on the prolongation of South Twenty-seventh street 810 feet from the easterly side of Pierce avenue; thence to a point on the prolongation of the southeasterly side of South Twenty-fourth street 1,020 feet from the northeasterly side of Pierce avenue; thence parallel to Pierce avenue to a point on the prolongation of the northwesterly side of South Twenty-first street; thence to a point on the prolongation of the northwesterly side of South Twentieth street 200 feet from the westerly side of the right of way of the California Southern Railway, measured at right angles to said line at this point; thence parallel to the same line of right of way, and distant therefrom 200 feet, to the prolongation of the westerly line of Columbus street; thence to a point on the prolongation of the westerly side of Arctic street 200 feet from the southerly side of H street; thence parallel to H street to the prolongation of the easterly side of Atlantic street; thence in an arc of a circle of 300 feet radius, whose center is at the northeast corner of H and Atlantic streets, to the prolongation of

* See Annual Report, Chief of Engineers, 1890, page 2904.
† Omitted.

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the northerly side of H street; thence parallel to Atlantic street to the prolongation of the northerly side of Cedar street; thence to a point on the prolongation of the southerly side of Hawthorne street 400 feet from the westerly side of California street; thence to a point on the prolongation of the southerly side of Palm street, 300 feet from the westerly side of California street; thence parallel to California street to the prolongation of the southerly side of Thorn street; thence to a point on the prolongation of the southeasterly side of Vine street 425 feet from the southwesterly side of California street; thence to a point on the prolongation of the southeasterly side of Wright street 530 feet from the southwesterly side of Atlantic street; thence to a point on a line 50 feet south of and parallel to the southeasterly side of Sutherland street prolonged 2,000 feet from the southwesterly side of Atlantic street; thence to a point on the line 50 feet south of and parallel to the southeasterly side of Sutherland street prolonged, 4,400 feet from the southwesterly side of Atlantic street; thence to a point on the prolongation of the southeasterly side of Noell street, 4,900 feet from the southwesterly side of Atlantic street; thence to a point on the prolongation of the northwesterly side of Bandini street, 5,400 feet from the southwesterly side of Atlantic street; thence to a point on a line 300 feet north of and parallel to the northwesterly side of Couts street prolonged, 5,200 feet from the southwesterly side of Atlantic street; thence to a point on the prolongation of the southeasterly side of Wetherby street, 3,600 feet from the southwesterly side of Atlantic street; thence to a point on the prolongation of the southwesterly side of Thirty-second street in Roseville, 2,900 feet from the southeasterly side of Main street, Roseville; thence to a point on the prolongation of the southwesterly side of Thirty-second street, 1,800 feet from the southeasterly side of Main street; thence to a point on the prolongation of the southwesterly side of Thirtieth street, 1,700 feet from the southeasterly side of Main street; thence to a point on the prolongation of the southwesterly side of Twenty-seventh street, 1,200 feet from the southeasterly side of Main street; thence to a point on the prolongation of the northeasterly side of Twenty-third street, 400 feet from the southeasterly side of Main street; thence to a point on the prolongation of the southwesterly side of Nineteenth street, 200 feet from the southeasterly side of Main street; thence to a point on the prolongation of the southwesterly side of Fourteenth street, 1,200 feet from the southeasterly side of Main street; thence parallel to Main street to the prolongation of the northeasterly side of Twelfth street; thence to a point on the prolongation of the southwesterly side of Eighth street, 500 feet from the southeasterly side of Main street; thence parallel to Main street to the prolongation of the northeasterly side of Sixth street; thence to a point on the prolongation of the southwesterly side of Second street, 1,100 feet from the southeasterly side of Main street; thence parallel to Main street to the prolongation of the southwesterly side of New Main street in New Roseville; thence to a point on the prolongation of the southeasterly side of Water street, 1,200 feet from the southwesterly side of New Main street, New Roseville; thence to a point on a line parallel to New Main street prolonged, and 1,900 feet westerly of its westerly side, 220 feet from the southeasterly line of Main street prolonged; thence to a point on a line parallel to New Main street prolonged, and 2,550 feet westerly of its westerly side, 380 feet southerly from the southerly side of Main street prolonged; thence to a point on a line parallel to New Main street prolonged, and 2,700 feet westerly from its westerly side, 920 feet from the southeasterly side of Main street prolonged; thence to a point on a line parallel to New Main street prolonged, and 3,930 feet westerly from its westerly side, 1,050 feet from the southeasterly side of Main street prolonged; thence to a point 110 feet due east, true meridian, from the corner stone of the United States military reservation at La Playa.

CORONADO.

Starting from a point on the prolongation of the easterly side of Prospect street, at a distance of 1,030 feet from the northerly side of Second street; thence to a point on the prolongation of the easterly side of Orange avenue, and 450 feet from the northerly side of First street; thence to a point on the prolongation of the westerly side of K street, 250 feet from the northerly line of First street.

SPANISH BIGHT.

For the purpose of describing the bulkhead lines in Spanish Bight a true meridian is assumed, passing through the U. S. Coast and Geodetic Survey triangulation station on the northeast extremity of Coronado North Island, called "Channel Point," survey of 1887; points being designated by their distances east or west of this line and north or south of the parallel of latitude passing through the triangulation station "Channel Point." The position of this station as determined by the U. S. Coast and Geodetic Survey in 1887 is latitude 32° 42′ 38.61″, longitude 117° 11′ 35.55″,

Starting from a point on the prolongation of K street, Coronado, 250 feet from the northerly line of First street, thence to a point 3,050 feet south and 1,800 feet east of Station "Channel Point;" thence to a point 3,850 feet south, 1,620 feet east of said Channel Point; thence to a point 4,000 feet south, 125 feet west of said Channel Point; thence to a point 4,450 feet south, 430 feet west of said Channel Point; thence to a point 5,330 feet due south of said Channel Point; thence to a point 6,770 feet south, 1,000 feet west of said Channel Point; thence to a point 8,320 feet south, 1,250 feet west of said Channel Point; thence to a point 8,150 feet south, 2,780 feet west of said Channel Point; thence to a point 6,150 feet south, 1,620 feet west of said Channel Point; thence to a point 6,000 feet south, 2,275 feet west of said Channel Point; thence to a point 4,400 feet south, 1,300 feet west of said Channel Point; thence to a point 3,300 feet south, 570 feet west of said Channel Point; thence to a point 120 feet due east of said Channel Point; thence in a quadrant of a circle of 120 feet radius, with the center at said Channel Point, to a point 120 feet due north of said Channel Point.

NORTHWESTERLY FRONT OF CORONADO NORTH ISLAND.

All points of the bulkhead and pier-head lines along this front are referred to straight lines connecting the triangulation stations on Coronado North Island, known as "Channel Point," "Middle," and "Mud," located by the U. S. Coast and Geodetic Survey in 1887. The connecting lines run from Channel Point to Middle and from Middle to Mud. For convenience of reference the points on these lines from which points on the bulkhead and pier-head lines are measured are designated by letters of the alphabet, the respective distances apart being as follows: From Channel Point to A, 500 feet; A to B, 500 feet; B to C, 500 feet; C to D, 500 feet; D to E, 1,000 feet; E to F, 1,000 feet; F to G, 1,000 feet; G to H, 1,000 feet; H to I, 1,000 feet; and along the second line from Middle to J, 1,000 feet; J to K, 1,000 feet; K to L, 1,000 feet; L to M, 1,000 feet; M to N, 1,000 feet; N to O (past Mud), 1,000 feet; O to P, 500 feet; P to Q, 500 feet; Q to R, 300 feet; R to S, 200 feet.

The distances of all points of change of direction of the bulkhead and pierhead lines are measured on lines at right angles to said connecting station lines at these respective points. The bulkhead line may therefore be described as follows:

Beginning at a point 120 feet due north of the triangulation station Channel Point, thence to a point 800 feet from A, thence to a point 1,150 feet from B, thence to a point 1,300 feet from C, thence to a point 1,300 feet from D, thence to a point 1,000 feet from E, thence to a point 730 feet from F, thence to a point 200 feet from Middle, thence to a point 200 feet from Middle, with reference to line from Middle through Mud, thence to a point 450 feet from J, thence to a point 600 feet from K, thence to a point 600 feet from L, thence to a point 400 feet from N, thence to a point 500 feet from O, thence to a point 800 feet from P, thence to a point 500 feet from Q, thence to a point on R on the connecting line Middle through Mud.

PIER-HEAD LINES.

The pier-head lines are laid out in straight stretches, following essentially the 24-foot contour, except south of the National City Wharf. It is not possible to follow this contour exactly. To avoid abrupt changes, and to interfere as little as possible with tidal currents, some departure from that contour has been made at a few points. This has had the effect of giving slightly increased or decreased depths at those points. The ruling depth, however, as adopted by the Board for the pier-head line is 24 feet, except south of the National City Wharf, where the ruling depth is taken at 18 feet.

In front of National City.—The approximate distance of the National City pier-head line from certain fixed points is as follows:

On the prolongation of southerly side of Thirty-first street, 4,600 feet from the westerly side of Eighth avenue; on the prolongation of southerly side of Twenty-fourth street, 3,650 feet from the westerly side of Eighth avenue; on the prolongation of the southerly side of Nineteenth street, 3,550 feet from the westerly side of Eighth avenue; at the southwesterly corner of present National City Wharf; on the prolongation of the southerly side of Ninth street, 3,600 feet from westerly side of Seventh avenue; on the prolongation of the boundary line between San Diego and National City, 3,350 feet from its intersection with the easterly line of Q avenue.

In front of San Diego.—Approximate distances from certain fixed points are as follows:

On prolongation of northerly side of Rigel street, 2,400 feet from northeasterly side of Q avenue; on prolongation of southeasterly side of South Twenty-eighth street, 1,390 feet from northeasterly side of Pierce avenue; on prolongation of northwest-

erly side of South Twenty-first street, 2,090 feet from northeasterly side of Pierce avenue; on prolongation of easterly side of Fifth street, 4,180 feet from southerly side of H street; on prolongation of westerly side of Atlantic street, 1,070 feet from southerly side of H street; on prolongation of southerly side of C street, 3,740 feet from westerly side of Atlantic street; on prolongation of northerly side of Ivy street, 6,850 feet from westerly side of California street; on prolongation of southeasterly side of Haraszthy street, 8,000 feet from southwesterly side of Atlantic street; on prolongation of southeasterly side of Sutherland street, 8,300 feet from southwesterly side of Atlantic street; on prolongation of southeasterly side of Wright street, 8,900 feet from southwesterly side of Atlantic street; on prolongation of southeasterly side of Couts street, 9,420 feet from the southeasterly side of Atlantic street.

In front of Roseville.—Approximate distances from certain fixed points are as follows:

On the prolongation of the southwesterly side of Fourteenth street, 5,500 from the southeasterly side of Main street; on the prolongation of the southwesterly side of Ninth street, 4,525 feet from the southeasterly side of Main street; on the prolongation of the southwesterly side of Fourth street, 3,950 feet from the southeasterly side of Main street; on the prolongation of the southwesterly side of New Main street, New Roseville, 3,650 feet from the southwesterly side of Main street.

In front of New Roseville and La Playa to the United States military reservation.—Approximate distances from certain fixed points are as follows:

On a line parallel to New Main street prolonged and 1,200 feet distant westerly from its southwesterly side, 3,000 feet from the southeasterly side of Water street prolonged; on a line parallel to New Main street prolonged and 2,000 feet westerly from its southwesterly side, 3,200 feet from the southeasterly side of Main street prolonged: on a line parallel to New Main street prolonged and 3,000 feet westerly from its southwesterly side, 3,050 feet from the southeasterly side of Main street prolonged; on a line parallel to New Main street and 4,000 feet westerly from its southwesterly side, 3,050 feet from the southeasterly side of Main street prolonged.

In front of Coronado.—Approximate distances from certain fixed points are as follows:

On the prolongation of the southeasterly side of Prospect place, 1,175 feet from the northeasterly side of Second street; on the prolongation of the southeasterly side of Orange avenue, 650 feet from the northwesterly side of First street; on the prolongation of the northwesterly side of K street, 1,300 feet from the northeasterly side of First street; a point 350 feet due north of triangulation point, Channel Point, on Coronado North Island.

In front of Coronado North Island.—Approximate distances from the points designated in describing the bulkhead line at this place are as follows:

A point 350 feet due north from Channel Point; 1,050 feet from A; 1,500 feet from B; 1,850 feet from C; 2,150 feet from D; 2,550 from E; 2,900 feet from F; 3,100 feet from G; 3,200 feet from H; 3,150 feet from I; 2,950 feet from Middle; 2,800 feet from Middle with reference to line running through Middle and Mud; 2,920 feet from J; 3,000 feet from K; 3,100 feet from L; 3,180 feet from M; 2,650 feet from N; 1,800 feet from O; 800 feet from Q; thence to S on the line Middle through Mud.

Respectfully submitted.

G. H. MENDELL,
Col., Corps of Engineers.
W. H. H. BENYAURD,
Lieut. Col, Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
June 21, 1892.

Respectfully submitted to the Secretary of War.

The harbor line board for San Diego Harbor and adjacent waters, California, constituted by paragraph 3, Special Orders No. 51, Headquarters, Corps of Engineers, October 11, 1888, recommends for the approval of the Secretary of War harbor lines at National City, San

Diego, Roseville, La Playa, Coronado, Spanish Bight, and Coronado North Island, described in the within report and delineated upon the accompanying chart.

It is recommended that the lines selected be approved and that the Secretary place his approval both upon the report and the tracing submitted.

These lines include the harbor lines established at San Diego and Coronado by the Secretary of War April 2, 1890.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

WAR DEPARTMENT, *June 21, 1892.*

The harbor lines described in the within report and delineated on the accompanying tracing are approved.

L. A. GRANT,
Acting Secretary of War.

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APPENDIX S S.

IMPROVEMENT OF SAN JOAQUIN, MOKELUMNE, SACRAMENTO, AND FEATHER RIVERS, PETALUMA CREEK, AND HUMBOLDT HARBOR AND BAY, CALIFORNIA.

REPORT OF MAJOR W. H. HEUER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. San Joaquin River, California.
2. Mokelumne River, California.
3. Sacramento and Feather rivers, California.
4. Petaluma Creek, California.
5. Humboldt Harbor and Bay, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal.., July 1, 1892.

GENERAL: I have the honor to transmit herewith annual reports of operations on the public works under my charge for the fiscal year ending June 30, 1892. * * *

Very respectfully, your obedient servant,

W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

S S 1.

IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

The project for the improvement of this river was adopted in 1877 and slightly modified in 1888. Its object was to secure and maintain by dredging a channel 9 feet deep at low water and 100 feet wide through the tidal portions of the river and Stockton Slough to Stockton; a channel 4 feet deep at low water and 100 feet wide to Miller's warehouse in Mormon Slough; the temporary improvement of the low-water channel by dredging, scraping, small wing dams, the making of cut-offs to straighten the river, and the closure or partial closure of Paradise Cut and Laird Slough.

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Up to June 30, 1892, the following appropriations have been made for this river:

August 14, 1876	$20,000	August 5, 1886	$18,750
June 14, 1880	20,000	August 11, 1888	25,000
March 3, 1881	40,000	September 19, 1890	75,000
August 2, 1882	40,000		
July 5, 1884	20,000	Total	258,750

Of this amount up to the present time there has been spent $257,886.69, of which $62,033.08 was spent in the last fiscal year.

Before the improvement of this river was commenced the low-water channel to Stockton was only about 6 feet in depth, while the upper river, above Stockton, was navigable to Hills Ferry for only a few months in the year during the high-water stage, and then only for boats drawing 2 feet or less of water. To-day the work of improvement has given a low-water channel of 9 feet to Stockton and rendered steamboating comparatively easy and safe. It has not, however, lengthened the time of navigation in the upper river.

The commerce of the river is carried on 10 steamboats of from 98 to 880 tons, averaging 462 tons, and drawing from 1½ to 6 feet of water, and on 14 barges of from 160 to 660 tons, averaging 300 tons.

Work on the river and sloughs has been continous whenever funds permitted.

Up to 1888 all the dredging, as well as other work, had been done by contract, and the cost of dredging varied from 46 to 15 cents per cubic yard. In 1888 the Government built a dredge and did the work by hired labor and has done so ever since. This has brought the cost of dredging down to less than 10 cents per cubic yard, and this year it has been less than 7 cents.

At the end of the last fiscal year the dredge was laid up in Stockton Slough.

The river having fallen considerably, the United States dredge was put in order and work resumed in Stockton Slough on October 27, 1891. This was continued until March 9, 1892.

To maintain the required channel to a depth of 9 feet at low water, cuts were made 50 feet wide of an aggregate length of 16.166 feet, and 153,530 cubic yards of material removed. To do this cost $10,526.16, or 6.8 cents per cubic yard.

On March 9, 1892, the river had risen so as to render further dredging unnecessary, and the dredge was shortly afterwards transferred to Lieut. Col. Benyaurd for work in Redwood Creek, California.

On May 15, 1891, a contract had been made with Charles L. Bigelow to build a dam across Laird Slough, in the San Joaquin River, but it was not until August that the river had fallen sufficiently to enable work to be commenced.

The slough is situate about 2 miles above the village of Grayson, quite an important grain-shipping point on the river. The junction of the slough and the river is at a very sharp bend in the latter, and at this locality the slough is fully as wide as the river, about 200 feet, and has a cross-sectional low-water area of about 1,000 square feet. That of the river above the slough is probably 25 per cent greater, while immediately below the upper end of the slough the low-water cross-sectional area was only 320 square feet. It was estimated in August, 1891, just before the dam was commenced, that fully 75 per cent of the river flowed through Laird Slough and reëntered the river by two branches of the slough at 1 and 2 miles, respectively, below the village of Grayson. The banks in this vicinity are apparently of hard pan.

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They are quite flat and generally about 10 feet above low-water level. The rise in flood stages is from 10 to 12 feet, both banks being overflowed.

The necessity of closing Laird Slough was first urged in 1888 by the navigation companies, who claimed that unless the flow of water through it was checked the crevasse would become the channel of the river and thus cut off the town of Grayson as a shipping point altogether.

The contract with Charles L. Bigelow was made on the following basis per unit of material: Piles, at 26 cents per linear foot; driving piles, at $7.20 each; brush, at 70 cents per cubic yard; sand bags in place, at 23 cents each; sand boxes in place, at $3.60 each.

Work was commenced on August 19, 1891, by driving two parallel rows of piles across the slough; the rows were 10 feet apart; the piles were 6 feet apart between centers, and each pile was driven as far as practicable into the bottom, generally penetrating about 26 feet in depth. Brush was cut, tied up into bundles from 12 to 20 feet in length, each bundle being from 12 to 15 inches in diameter. These bundles were then placed across the current between the rows of piling to a height of about 4 feet. This formed a sort of brush mattress, which was sunk to the bottom of the stream by means of loaded sand bags. While sinking the lower mattress a considerable scour occurred in the bottom and one flank of the dam. This was checked by throwing in additional brush and bags of sand. When the bottom had thus been protected with brush between the piles similar mattresses were sunk in contact with the first on both the up and down stream sides of the dam, the banks in the immediate vicinity of the dam were revetted with brush, held down by sand in bags, and the work was thus carried on in tiers of brush mats until the desired height was obtained. Waling pieces and stringers were then bolted and spiked to the piles and the crest of the dam was covered with boxes, each 10 feet long by 20 inches wide by 15 inches deep, each divided into 5 separate compartments and filled with sand. The tops were then nailed on and each box was fastened to its neighbors by nailed battens. In this manner 9,737 cubic yards of brush, 14,000 sacks of sand, 186 boxes of sand, and 54 piles aggregating 2,259 running feet entered into the construction of the dam. At its crest the dam is 10 feet deep and 310 feet in length; at its base the thickness is about 60 feet. The crest is 10 feet above low-water stage in the middle and raises gradually 2 feet higher at the bank. The upstream slope of the dam is 1 on 1; the downstream slope is about 1 on 3. The water on the upstream side of the dam is 3 feet higher than on the lower side. The leakage through the brush is very slight. The work was completed on September 29, 1891, in forty-one working days, and cost $11,994.38, of which amount $312.74 is chargeable to engineering expenses, superintendence, advertising, and contingencies, or about 2.6 per cent.

The dam was examined on May 29, 1892, when the San Joaquin River was in flood, about 10 feet above its low-water mark. The river was about bank full and level with the tops of the piles in the dam, and although the water was pouring over the dam it was perfectly intact and every pile in place. On June 3 or 4, 1892, a breach occurred in the east bank of the slough, undermining about 50 linear feet of shore-protection work at the eastern extremity of the dam. This breach should be repaired, but as the extent of the damage can not yet be determined it is impossible to estimate the cost.

At the end of the last fiscal year contract had been made with John W. Ferris for building a dam across the crevasse known as Paradise

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Cut, but work had not been commenced. The contract was made at the following prices per unit of material and based on the following assumed quantities:

7,900 feet of piles, at 21 cents per foot	$1,575.00
Driving 155 piles and fastening wales to same, at $4.75	736.25
6,000 cubic yards brush in place, at 67½ cents per cubic yard	4,050.00
10,000 bags of sand in place, at 15 cents each	1,500.00
350 boxes of sand in place, at $3.50 each	1,225.00
1,000 tons of rock in place, at $3.30 per ton	3,300.00
1,000 running feet wale pieces, at 12½ cents per running foot	125.00
	12,511.25

Actual construction was commenced early in August and the dam was finally completed and accepted on November 13, 1891.

The dam is situated within and across Paradise Cut, about 100 feet distant from the left bank of the San Joaquin River, and consists of piles of brush and rock ballast. The piles for the main weir are driven in four parallel rows across the stream; the rows are 10 feet apart, the piles in each row being 6 feet between centers; each pile is driven into the bottom of the cut an average distance of 26 feet. The crest of the weir is 8 feet above low-water level of the San Joaquin River; its length along the crest is 220 feet. On the prolongation of the crest of the weir on both sides of the river are flanks whose crests are 8 feet higher than that of the weir, and whose lengths are 50 and 72 feet, respectively.

These flanks consist of two rows of piles driven into the sloping banks of the cut and on the shore. The rows are 10 feet apart and the piles of each row 6 feet between centers.

Piles were also driven across the bottom and sides of the cut for a distance of 20 feet in front of the dam and 40 feet behind the dam to confine brush mats to the approach and overfall sides of the structure, as well as to protect the banks from washing. When the 322 piles which compose the skeleton of the dam were all driven, a temporary dam 108 feet long of sheet piling was made between the weir and the San Joaquin River and the great mass of water in Paradise Cut was pumped out so as to expose the bottom at the weir site and enable it to be prepared in a suitable manner to receive the brush. Brush (green willow in bundles) was then placed all along the bottom between all piles of the weir, dam, approaches, and overfall, the direction of the axes of the bundles of the brush being always parallel to the crest of the weir. Each bundle, after being placed in position, was cut and packed down as snugly as was practicable, and thus tier after tier of brush was built up until the mattresses of the approach and overfall were 4 feet in vertical height; that between the first and second rows of piles in the weir proper was, at reference, 8 feet; that between the second and third rows was, at reference, 6 feet, and that between the third and fourth rows, at reference, 4 feet above mean low-water level in San Joaquin River. The flanks were filled with brush to reference 16 feet. When the brush was thus placed throughout the dam all piles had wale pieces and caps bolted to them so as to form a series of cribs, and on top of this brush rock, in pieces varying in weight from 300 pounds to 1 ton, was placed until all the rock, aggregating 1,166 gross tons, was in position. This rock compressed the brush very materially, and in places the column of rock was nearly 10 feet in vertical height. No rock was placed in the approaches or overfall apron, the brush therein being held down by waling pieces bolted to the piles themselves.

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Two short earthen levees run along the banks of Paradise Cut, one of the flanks of the dam connects with one levee, and a crib 30 feet long, filled with earth, connects the dam with the other levee.

	Feet.
The total length of weir is	220
Length of prolongation of north flank	50
Length of prolongation of south flank	72
Length of crib on south bank	30
Total length	372
Width of mat on approach side	20
Extreme width of mats on south side of bank	80
Length of face of south wing	60
Distance from dam to extreme end of north wing	60
Width of mat at overfall	40

Banks covered with brush on both sides at overfall for a distance of 50 feet.

There is in the work the following amount of material: 9,026.46 cubic yards of brush; 1,166 gross tons of rock; 322 piles, round and square. No payment was made for square piles except for driving as they came from the old dam; 7,055 linear feet of round piling; 90 posts for securing brush in shore protection; 1 crib at end of dam.

The amount of money paid to contractor for work done was $11,079.55.

There are sent herewith photographs showing both the upper and lower view of the dam.

Owing to compression of the brush and some settlement, it will be desirable to again raise the crest of the dam to its original height by brush and ballast. Estimated to cost $2,000.

On July 6, 1891, contract was made with John W. Ferris to dredge a cut-off at Head Reach, a bend in the river about 26 miles below Stockton, for 11¾ cents per cubic yard, measured in place in the cut. Work was commenced immediately and continued until October 6, when it was stopped until the banks, which were very soft, had time to dry out sufficiently to bear the weight of additional material. By this time the cut had been carried completely through, a distance of 3,084 feet, with a least width of 150 feet and depth of 7 feet at low water. To make this cut 210,132 cubic yards of material were excavated and placed on shore. In December, 1891, the banks having dried and hardened, work was resumed, and on December 29, 1891, the contract was completed, an additional 16,800 cubic yards of material having been dredged and put on shore. The cut, as completed, is 3,084 feet in length, with a least width of 150 feet between banks. The approaches to the cut have widths of 234 and 215 feet, respectively. The depth is 7 feet at low water, with an additional cut through the center, 70 feet wide, and 9 feet at low water, making a practical channel 9 feet deep at low water.

This cut-off is a complete success, and is used by all craft going up and down the river. The total cost of it was $27,234.41. It is proposed, when more money is appropriated, to widen and deepen this cut as projected. Estimated cost, $37,750.

Previous Annual Reports have recommended a cut-off at Twenty-one Mile Slough at a cost of $65,000, but no appropriation has been made for the purpose. A double cut-off in the narrows in the river just below the junction of Stockton Slough and the San Joaquin River would also be highly beneficial, as since the improvement of the river larger and longer boats have been built, and these with great difficulty make the sharp bends. In case this cut-off should be made it is recommended that it should have a cross-sectional area about equal to that of the river in the immediate vicinity. This would give it a width of about 150 feet and a uniform depth of 9 feet at low water. This would involve the removal of approximately 11,700 cubic yards of ma-

terial at an estimated cost of $20,000. This is exclusive of the purchase of the right of way, and as this cut-off, if made, will be of great benefit to the people living in Stockton, by facilitating the tidal movements of the water in seasons of flood, it is thought that the right of way for the proposed cut should be deeded to the Government free of expense.

Wherever cut-offs have been made they have been self-maintaining.

Annual dredging will be necessary to keep Stockton Slough in a navigable condition; in fact, without it, in a short time, steamboats would be unable to reach Stockton.

While it can not be asserted that any reduction in the rates of freight or insurance have been made in consequence of the improvements, it is probable that if they were discontinued a considerable increase would soon follow. It is certain that the work done has been of the greatest benefit to the navigation of the river generally, and particularly to the city of Stockton.

With any future appropriations, depending on the amounts appropriated and the requirements of commerce, it is proposed to continue work in the following order, unless Congress should otherwise direct:

1. Dredging to maintain 9 feet depth to Stockton	$25,000
2. Repairing dam at Paradise Cut	2,000
3. Making a cut-off at Twenty-one Mile Slough	65,000
4. Making a double cut-off below the mouth of Stockton Slough	20,000
5. Increasing cut at Head Reach, in depth, width, or both	37,750
6. Survey of upper river to Firebaughs Ferry	5,000
7. Snagging and wing dams	10,000
Total	164,750

The above amounts could be advantageously expended in one fiscal year.

Money statement.

July 1, 1891, balance unexpended	$63,002.53
June 30, 1892, amount expended during fiscal year	62,033.08
July 1, 1892, balance unexpended	969.45
Amount appropriated by act approved July 13, 1892	65,000.00
Amount available for fiscal year ending June 30, 1893	65,969.45
Amount (estimated) required for completion of existing project *	
Amount that can be profitably expended in fiscal year ending June 30, 1894	164,750.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

COMMERCIAL STATISTICS.

The following statistics of the trade of the San Joaquin River were kindly supplied by Capt. H. J. Corcoran, manager of the California Navigation and Improvement Company, who own most of the steamboats and barges running on the river. A large amount of freight is carried between San Francisco and Stockton in small schooners, and of this it is impossible to get a correct statement:

	Tons.
Wheat	70,000
Lumber	86,000
Coal	45,000
Mill stuffs	69,000
Miscellaneous freight and manufactured products	50,000
Produce	30,000
Pulp, hides, and other raw materials for manufacturing purposes	20,000
Total	370,000
Passengers	56,000

* Indeterminate.

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S S 2.

IMPROVEMENT OF MOKELUMNE RIVER, CALIFORNIA.

Before improvement the navigation of this river was difficult and dangerous on account of numerous snags and overhanging trees, and in 1884 a project for its improvement was made, having for its object the removal of the snags and trees obstructing navigation. Both forks of the river were cleaned out in 1884, 1885, 1886, 1887, and 1888, rendering travel to Bensons Ferry, the head of navigation, easy and safe. This completed the project as outlined, and since then no work of improvement has been done on the river.

The following are the appropriations made for this river:

1884, July 5	$8,500
1886, August 5	2,500
1888, August 11	2,000
Total	13,000

Of this amount $12,457.62 has been expended up to the present time. Nothing was spent in the last fiscal year.

Since 1888 snags have reformed, which require removal, and overhanging trees have regrown. These should be again cleared out. Private parties have also cut a drainage canal, opening into the river near New Hope Landing. This has caused a serious bar to form, which makes the landing of boats difficult. The remedy is to compel the closure of the ditch and remove the bar by dredging.

Another obstruction is a point of land jutting out into the channel on the right bank near New Hope Landing. This landing, one of the most important shipping points on the river, is on the left bank of the river proper, at the junction of the two forks. From this point a pontoon bridge extends across the south fork of the river, which fork for a mile and a half below this point is not navigable. The river proper and the north fork at New Hope Landing make a junction which is nearly a right angle. The point of land referred to, being a tongue between the river and the north fork, is gradually but constantly extending into the fork, increasing the curvature of the bend, and, in consequence of the current, making it very difficult for a boat to make the landing at New Hope. To make the landing easy and safe and give a more direct entrance for the river into the north fork, this point, which contains about two-thirds of an acre, should be removed to a depth of 6 feet below low water.

The estimated cost of the improvements referred to is as follows:

Removing snags and overhanging trees	$2,000
Pile and brush dam to close drainage canal	1,000
Removing sand bar caused by canal, 50,000 cubic yards, at 10 cents	5,000
Cutting off point near New Hope Landing, including grubbing and purchase of land	1,100
Total	9,100

All this work could be advantageously done in one fiscal year.

The statistics of trade, furnished by the California Transportation Company, for the Mokelumne River for the year from June 1, 1891, to June 1, 1892, are as follows:

Freight	tons	44,241
Passengers		3,669

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This commerce is carried on one stern-wheel steamer, the *Constance* (385 tons; draft, light, 2½ feet; loaded, 6 feet), which makes three round trips per week and carries all the freight offered. The effect of the improvements on the rates of freight and insurance is uncertain, but as the rate of freight by river is $1 per ton less than by railway from competing points, a yearly saving is effected on the above statement of freight of $44,241.

Money statement.

July 1, 1891, balance unexpended	$542.38
July 1, 1892, balance unexpended	542.38
Amount appropriated by act approved July 13, 1892	2,500.00
Amount available for fiscal year ending June 30, 1893	3,042.38
Amount (estimated) required for completion of existing project	6,600.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	6,600.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

S S 3.

IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS, CALIFORNIA.

The Sacramento River is a navigable stream from McIntosh Landing to the mouth of the river, a distance of 230 miles. Formerly it was navigable 45 miles farther upstream, to Red Bluff, but since the railroads have been in operation the boats have not found it commercially profitable to go above McIntosh.

The Feather River is a tributary of the Sacramento, entering that river about 16 miles above the city of Sacramento. It is a navigable stream up to its junction with the Yuba River, at the town of Marysville, a distance of 30 miles.

Before improvement navigation in these rivers was dangerous, on account of numerous bad snags, shallow bars, and rapids, and in 1874 a project for improvement was made and approved. It had for its object the temporary improvement of the low-water channel, by removing snags, building wing dams, and scraping bars. Work on this project has been continuous ever since whenever funds were available.

The following appropriations have been made for these rivers:

1875, March 3	$15,000	1884, July 5	$40,000
1878, June 18	15,000	1888, August 11	20,000
1879, March 3	20,000	1890, September 19	30,000
1880, June 14	45,000		
1881, March 3	60,000	Total	495,000
1882, August 2	250,000		

There has been expended up to the present time $481,680.99, of which $12,846.44 was expended during the last fiscal year.

At the commencement of the present fiscal year the snag boat *Seizer* was at work in the Upper Sacramento River and continued until September 11, 1891, when she was again laid up at Sacramento. During the season's work, which lasted ninety-one days, she removed and destroyed 974 snags, built 5 wing dams in the shallows below Placer City, aggregating 536 feet in length, and ran 914 miles. She consumed during the work 89½ tons of coal.

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The cost of the work was $10,719.54.

This left the river in good condition to the head of navigation, and steamboating was uninterrupted.

In June 1892, the river having again fallen, numerous snags brought down by the winter floods began to show themselves. The snag boat *Seizer* was accordingly again put in commission and sent to the upper river, where she is now at work.

The snagging during the present fiscal year has been under the charge of Assistant Engineer H. L. Demeritt, C. E., and the work has been satisfactorily and well done.

The commerce of the Sacramento River is carried on 8 steamers, 14 grain barges, and 7 brick barges belonging to the Sacramento Transportation Company; 5 steamers and 7 barges belonging to the California Transportation Company; and 2 steamers belonging to the Southern Pacific Company. The steamers vary in size from 183 to 619 tons, averaging 303 tons, and the barges from 115 to 800 tons, averaging 581 tons. The larger of the steamers only go a short distance up the river, the commerce of the Upper Sacramento being carried on barges towed by small, light-draft steamboats.

On the Feather River a small steamer, 247 tons gross tonnage, belonging to the Southern Pacific Company, makes one round trip per week, with a barge, and carries all the freight that offers.

The snagging heretofore done had been of great benefit to navigation; without it, in fact, steamboating in the upper Sacramento River would be impossible. Freight and insurance rates have been greatly reduced in consequence, and navigation is now safe.

At present all that has been attempted in these rivers is the temporary improvement of the low-water channels, and Congress by its appropriations has contemplated nothing more. To even continue this, annual snagging must be carried on or traffic in the upper Sacramento will be stopped.

The river and harbor act of September, 1890, provided for a Board of Engineers to examine and report on the Sacramento and Feather rivers, with a view to their future improvement. Their report has been printed as House Ex. Doc. No. 246, Fifty-first Congress, second session,* and contains information as to the condition and requirements of these rivers, to which attention is respectfully invited.

The following appropriations are recommended therein:

(1) A specific yearly appropriation of $25,000 for snagging, building wing dams, etc., by means of the snag boat and crew, above the city of Sacramento.

(2) A specific appropriation of $275,000 for removal of obstructions in the lower Sacramento River, and $25,000 for the closure of Jacobs Slough, on the east bank of the river, above the city of Sacramento.

(3) A specific appropriation of $300,000 for treatment of the Yuba River, near and above Marysville.

(4) A specific annual appropriation of $20,000 for improving the navigable channel of the Feather River.

Of these amounts the whole of items Nos. 1, 2, and 4, and $100,000 of item 3, making a total of $420,000, can be advantageously expended during the fiscal year ending June 30, 1894.

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* Printed also in Annual Report, Chief of Engineers, 1891, page 2990.

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Money statement.

July 1, 1891, balance unexpended	$26,165.45
June 30, 1892, amount expended during fiscal year	12,846.44
July 1, 1892, balance unexpended	13,319.01
July 1, 1892, outstanding liabilities	350.00
July 1, 1892, balance available	12,969.01
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	162,969.01
Amount (estimated) required for completion of existing project* Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	420,000.00

COMMERCIAL STATISTICS.

The following is a return of the freight carried on the Sacramento River by the California Transportation Company during the year from June 1, 1891, to June 1, 1892, kindly furnished by the company. Their boats only run as far as Clarksburg, about 35 miles above the mouth of the river:

	Tons.
Merchandise, fruit, produce, etc	86,347
Lumber	19,000
Total	105,347
Passengers	14,455

The following is the amount of freight carried by the steamers of the Southern Pacific Company between San Francisco and Sacramento, including all way-freight, kindly furnished by Mr. E. C. Wright, general auditor of the company:

	Tons.
Freight taken north	60,424
Freight taken south	61,343
Total	121,767

The following is the amount of freight carried by the boats and barges of the Sacramento Transportation Company, kindly furnished by the president of the company:

On the lower Sacramento River:

	Tons.	
Wheat and other grain brought from the upper river for Port Costa and San Francisco		102,040
Wood brought from upper river for San Francisco		11,250
Merchandise brought from San Francisco to be taken to upper river		11,440
Lumber brought from San Francisco to be taken to upper river		4,000
		128,730
Merchandise between San Francisco and Sacramento	20,000	
Coal, San Francisco to Sacramento	12,000	
Lumber, San Francisco to Sacramento	13,000	
Brick, Sacramento to San Francisco	50,000	
		95,000
Total carried on lower river		223,730

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*Indeterminate.

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On the Upper Sacramento River:	
Wheat, down river	102,040
Wood, down river	11,250
Merchandise, up river	11,440
Lumber, up river	4,000
Total carried on upper river	128,730
Total tonnage of Lower Sacramento River for year	450,840
Total tonnage of Upper Sacramento for year	128,730

The following is the freight carried on the Feather River during the year, kindly furnished by Mr. E. C. Wright, General Auditor of the Southern Pacific Company, on whose boat the freight was carried:

	Tons.
Freight taken north	3,911
Freight taken south	13,030
Total	16,941

This is the total tonnage of the Feather River for the year.

S S 4.

IMPROVEMENT OF PETULUMA CREEK, CALIFORNIA.

The project for the improvement of this creek was made in 1880. Its object was to straighten the channel by cut-offs, and to obtain, by dredging, a channel 50 feet wide and 3 feet deep at low water, up to the town of Petaluma. Up to the present time $36,000 have been appropriated for the improvement of this creek, of which amount $35,892.95 has been spent in completing the project, leaving a balance yet on hand of $107.05.

The following appropriations have been made for this work:

1880, June 14	$8,000
1881, March 3	8,000
1882, August 3	14,000
1888, August 11	2,000
1890, September 19	4,000
Total	36,000

Before improvement the channel was very crooked, and in places bare at low water. Dredging was done by contract in 1880 and 1881, at 29 cents and 45 cents per cubic yard; 21,135 cubic yards of material were removed from cut-offs and from channel. In 1882 and 1883 25,290 cubic yards of material were dredged at 25½ cents, and in 1883 and 1884 43,267 cubic yards were dredged, completing the project. The estimate for completing the project was $25,868; the actual cost of completing the project was $27,656.91.

In 1888 the channel refilled and was again redredged at a cost of 25 cents per cubic yard, or $2,116.39. This gave a channel about 40 feet wide and 1 foot deep at low water and partially relieved the immediate wants of navigation. The channel again deteriorated and in 1891, when further funds became available, a contract was made for redredging a channel at 15 cents per cubic yard.

On this last contract work was commenced in August, 1891; the result was a completed channel 6,800 feet long and 40 to 45 feet in width. Of this length 4,200 feet was excavated to a depth of 3 feet below the lowest low water, while the other 2,600 feet was dug to a depth of 28 to 30 inches below the same plane. Much of the dredging was in hard-pan.

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The appropriation was insufficient to complete the whole work to the greater depth. The excavated channel extends from the railroad bridge below the town up to the steamboat wharf in the town. Since the channel was completed there has been no detention therein of boats on account of lack of water. The cost of this last piece of work was $5,846.36, and 37,025 cubic yards of material were removed from the channel. Experience has proved that this channel is not self-maintaining, and navigation can only be kept up by occasional dredging. Nearly all the drainage of the creek flows over highly cultivated agricultural land, in consequence of which deposits are large. The creek carries a very large commerce, as can be seen by the statistics herewith, and is sufficiently large to warrant the securing of a channel 4 to 5 feet deep at low water, to obtain which it is estimated will cost about $30,000. As this channel will not be self-maintaining it will have to be redredged about once in every five years at an estimated cost of $5,000.

The commerce of the creek is carried on one stern-wheel steamer, the *Gold*, of about 294 tons, which makes six round trips per week, and many small schooners which carry the heavier freight.

Money statement.

July 1, 1891, balance unexpended	$5,953.41
June 30, 1892, amount expended during fiscal year	5,846.36
July 1, 1892, balance unexpended	107.05
Amount appropriated by act approved July 13, 1892	10,000.00
Amount available for fiscal year ending June 30, 1893	10,107.05
Amount (estimated) required for completion of existing project*. Amount that can be profitably expended in fiscal year ending June 30, 1894. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

COMMERCIAL STATISTICS.

The following statistics of the trade of Petaluma Creek are taken from a report of a committee appointed by the board of trustees of the city of Petaluma for the purpose of collecting such statistics, and kindly furnished by them:

	Tons.		Tons.
Grain	24,000	Lumber	5,531
Coal	2,272	Mill stuff	10,020
Merchandise	25,845	Live stock	2,392
Produce	28,606		
Cannery products	6,348	Total	105,114
Iron	100		

Passengers, 6,460.

S S 5.

IMPROVEMENT OF HUMBOLDT HARBOR AND BAY, CALIFORNIA.

The project for this improvement was adopted in 1881, and had for its object the securing of a channel 13 feet deep and 200 feet wide to the head of Eureka wharves, and one 10 feet deep and 100 feet wide to Arcata and Hookton. This portion of the project was completed in

* Indeterminate.

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1884, at a cost of $96,061.55. These channels have since deteriorated somewhat, but not sufficiently to impede navigation.

In 1882 an additional project was made, contemplating the increase of depth over the bar at the entrance to the harbor by means of a stone jetty built up to low water and extending seaward from the south spit for a distance of 6,000 feet. The estimated cost of this was $600,000. In October, 1890, a Board of Engineer Officers, appointed to consider this work, advised the modification and increase of this project to embrace two stone and brush jetties starting from the shores of the north and south spits and extending seaward to the 18-feet curve. The estimated cost of the two jetties was $1,957,615. This project was adopted. Appropriations for improving the entrance aggregating $342,000 were made in the years 1884, 1886, 1888, and 1890; but as the amount for any one year was too small to warrant commencement of work, and, moreover, by a clause in the act money was not available until title to land on the south spit was acquired free of expense to the Government, nothing was done until 1888, when the land required was obtained and a contract let to the American Bridge and Building Company for work on the south jetty. Under this contract, which as extended expired October 31, 1890, 1,605 feet of shore track, 1,152 linear feet of protection work, and 2,767.6 linear feet of pier over water were built; from this latter 14,669 cubic yards of brush mattress, weighted with 44,943.5 tons of stone, were placed, building the jetty out 2,767.6 feet and raising it to the level of high water for 900 feet of that distance. In May, 1891, operations were commenced under a contract made with Messrs. Simpson & Brown in the preceding February, and work was vigorously prosecuted until the expiration of the contract in December, 1891. Up to June 30, 1891, the contractors had delivered in the south jetty 8,168 tons of stone, which were used in raising that jetty to a high-water plane out from 900 feet reference to 1,800 feet. Early in May the erosion of the north spit caused the widening of the entrance from 4,200 to 5,600 feet, the forming of a shoal in the north channel, and became so serious that it was determined to transfer operations to that point, and in June the contractor prepared to commence work by building a wharf and approaches, laying shore track, and driving piles needed for the construction of the jetty. All this was ready by the commencement of the present fiscal year.

North Spit.—In July it was found that a succession of high tides with heavy seas caused an erosion of the bank in the vicinity of the end of the shore track making its protection necessary. This was done by building 300 linear feet of protection work requiring 252.24 cubic yards of brush mattress and 150 tons of stone. Work was begun on the jetty proper and continued until September, when a spur raised to high-water level had been run out 1,480.5 feet in a southerly direction; this consisted of a trestle and track, from which brush mats weighted with stone were sunk. This was found to be sufficient to arrest the erosion and cause the North Spit to reform, as the sand on the seaward side was deposited to the top of the stone in one tide after dumping. In construction of this jetty it was found practicable, owing to the decreased action of the waves, to use two brush mattresses, one sunk on top of the other, and thereby lessen the amount of stone. This effected a saving of 6 tons of stone per running foot.

South Spit.—The operations here were confined to raising the jetty already built to 6 feet above low water, and in building an extension of some 600 feet. Progress was slow until after the north jetty was completed for the season, about the 15th of September, when operations

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were vigorously pushed to the end. This jetty is now 3,699.2 feet in length, of which 3,200 feet is completed up to high-water level. The outer portion slopes from high-water level for a length of 499.2 feet to a depth of 7 feet below low water. During the construction of the extension a scour commenced off the end of the trestle, and at one time the depth was 18 to 20 feet, necessitating the use of piles 60 feet in length. Fears were entertained that this scour might continue and make the further prosecution of the work very expensive, but this proved to be unfounded, as the conditions shortly afterwards changed, and the water again shoaled as the work proceeded.

The following is the amount of the different items delivered into the jetties during the fiscal year, at a cost of $156,413.68:

	North jetty.	South jetty.
Track way on shore.....feet..	1,486	.....
Trestle and track over water.....do....	1,480	659.5
Brush mattress.....cubic yards..	8,777.18	4,759.95
Stone.....tons..	15,930	30,778

One apron and wharf on North Spit.

The above work being finished by October 31, and being the amount contemplated in the contract, operations were stopped and will not be resumed until a fresh appropriation is available, as the amount of funds on hand, $28,112.77, are not sufficient to warrant entering into a new contract.

As the south jetty is not yet extended to half the estimated distance, and the north one only commenced, it is hardly to be expected that very material results as to increased depth over the bar would be produced, yet as an indication in that direction the fact is noted that for the past year there has been a channel of 18 to 20 feet depth maintained, a condition never before known for so long a period in the history of this work.

Three tracings are sent herewith showing the progress of the work.

With the funds now on hand and any further appropriations that may be made it is proposed to continue the construction of both jetties, extending them out to the 18 foot-curve, a distance of 7,800 feet and 6,750 feet for the south and north respectively. The total cost of this work, less the amount already appropriated, is estimated to be $1,715,115, of which amount $700,000 can be used to advantage in the next fiscal year, it being cheaper to prosecute the work with all possible dispatch. Owing to the ravages of the teredo the life of the piles supporting the trestle can not be expected to exceed three or four years, and further, any contractor bidding on this work calculates so as to reimburse himself for the outlay in his plant, costing $40,000 to $50,000 in every contract, it is therefore manifestly cheaper to the Government to complete the work as soon as possible.

The following appropriations have been made for the improvement of Humboldt Harbor and Bay, California:

March 3, 1881	$40,000
August 2, 1882	40,000
Since estimates for training wall were made:	
July 5, 1884	62,500
August 5, 1886	75,000
August 11, 1888	125,000
September 19, 1890	80,000
Total	422,500

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Money statement.

July 1, 1891, balance expended	$184,525.45
June 30, 1892, amount unexpended during fiscal year	156,412.68
July 1, 1892, balance unexpended	28,112.77
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	178,112.77
Amount (estimated) required for completion of existing project	1,565,115.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	522,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

COMMERCIAL STATISTICS.

The following statistics of trade of Humboldt Bay, from June 1, 1891, to June 1, 1892, are approximate calculations taken from information kindly furnished by the secretary of the Humboldt board of trade at Eureka, Cal.:

Number of departures, steam vessels	291
Number of departures, sailing vessels	442
Total	733
Exports:	Tons.
Lumber	304,329
Produce	17,508
Merchandise	648
Live stock	408
Total	322,893

Of the above lumber 17,132 tons, valued at $155,287.10, were shipped direct to foreign ports, and 7,424 tons, valued at $89,546, were sent to San Francisco to be reshipped from there to foreign ports on vessels of too deep a draft to enter Humboldt Bay.

Foreign imports, direct:	
Coal ... tons	2,155
Passenger traffic:	
Arrivals	6,875
Departures	5,821
Total	12,696

The following is a statement of the freight carried by the steamer *North Fork*, making regular trips between San Francisco and Humboldt Bay, during the year from June 1, 1891, to June 1, 1892, kindly supplied by Capt. Charles Nelson, the agent of the steamer:

San Francisco to Humboldt Bay:	Tons.
General merchandise	5,127
Humboldt Bay to San Francisco:	
General merchandise	382
Lumber	12,760
Shingles	3,720
Shakes	2,610
Total	24,599
Passengers:	
San Francisco to Eureka	524
Eureka to San Francisco	707
Total	1,231

The following is a statement of the freight, passengers, and treasure carried by the boat of the Pacific Coast Steamship Company, making one round trip per week

between San Francisco and Humboldt Bay, kindly furnished by Messrs. Goodall, Perkins & Co.

Freight	tons	22,727
Passengers		6,243
Treasure		$443,289

The steamer *Humboldt*, owned by the Humboldt Steamship Company, also makes regular weekly trips between San Francisco and Humboldt Bay. Application was made for the statistics of freight carried by her and the information was promised by the agents; it was not, however, received in time to be included in this report.

The total tonnage of Humboldt Bay for the past year is estimated to have been 375,000 tons.

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APPENDIX T T.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS IN OREGON AND WASHINGTON.

REPORT OF CAPTAIN THOMAS W. SYMONS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Coquille River, Oregon.
2. Entrance to Coos Bay, Oregon.
3. Umpqua River, Oregon.
4. Mouth of Siuslaw River, Oregon.
5. Entrance to Yaquina Bay, Oregon.
6. Tillamook Bay and Bar, Oregon.
7. Entrance to harbor at Nehalem Bay, Oregon.
8. Upper Columbia and Snake rivers, Oregon and Washington.
9. Columbia River between head of Rock Island Rapids and foot of Priest Rapids, Washington.
10. Chehalis River, Washington.
11. Skagit, Stillaguamish, Nooksack, Snohomish, and Snoqualmie rivers, Washington.

EXAMINATIONS AND SURVEYS.

12. Olympia Harbor, Washington.
13. Tillamook Bay and Bar, Oregon.
14. Swinomish Slough, Washington.
15. Ship canal to connect Lakes Union, Washington, and Samamish with Puget Sound, Washington.

HARBOR LINES.

16. Establishment of harbor lines in Olympia Harbor, Vancouver Harbor, and Bellingham Bay, Washington.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, July 12, 1892.

GENERAL: I have the honor to forward herewith annual reports * * * for the fiscal year ending June 30, 1892, for the following works of improvement of rivers and harbors under my charge.

* * * * * * *

Very respectfully, your obedient servant,
THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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T T 1.

IMPROVEMENT OF COQUILLE RIVER, OREGON.

Description of original condition.—At the time the work of improvement was begun the entrance to the Coquille River was considered very dangerous. It was by a long, tortuous, and narrow channel, skirting the south headland, studded with rocks from beyond the bar on the outside to a distance of one-half mile inside. The depth at low water was only about 3 feet, and the position of the bar channel was constantly shifting. The channel sometimes, at long intervals apart, broke through the north spit and ran directly out to sea just south of Rackliffe Rock, but did not remain long in this position. The entrance at such times was comparatively safe and the channel was at its very best. The mean rise of tide was 4.1 feet.

Plan of improvement.—The plan of the improvement is to construct two parallel high-tide stone jetties, 600 feet apart, running out to sea a sufficient distance to open and maintain a channel over the bar with a least depth of 8 feet at low water, the north jetty starting from Rackliffe Rock and the south jetty from a point on the left bank inside the entrance. The cost of this work, as estimated in 1878 by Major J. M. Wilson, is $164,200. The law of August 11, 1888, authorized in addition $5,000 to be expended for snagging between Coquille City and Myrtle Point.

The law of September 19, 1890, authorized an amount not to exceed $3,000 to be used in snagging.

Under date of May 8, 1891, the plan of improvement was changed to provide for an entrance width of 600 feet instead of 800 feet.

A careful estimate of the cost of completing the works at the entrance to the Coquille in accordance with the plan of improvement given above has been made, and it is found to be $180,000. The correspondence on this subject is given under the head of "Recommendations and remarks."

The approved estimate of the cost of completing the work is $180,000.

APPROPRIATIONS.

Act of—	
July 14, 1880	$10,000
August 2, 1882	10,000
July 5, 1884	10,000
August 5, 1886	20,000
August 11, 1888	25,000
September 19, 1890	30,000
Total	105,000

Amount expended to June 30, 1891.—The amount which had been expended on the project for the improvement of the mouth of the Coquille to June 30, 1891, was $77,012.61, and the amount expended for snagging was $6,883.90, a total of $83,896.51.

Results obtained to June 30, 1891.—The entrance has for considerable periods been straight and with a depth of from 8 to 10 feet at low water, but winds and currents have at other times heaped the movable sands into the channel, causing the waters to spread out over a wide angle, or the channel to break away to the northward, shallow in depth and bad in direction. A study of the various changes at the mouth of the Coquille led to the belief that the best results could not be attained unless the channel was kept from breaking away to the north and the

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northern sands were kept from encroaching on the channel. It was therefore decided to use the present appropriation in building the north jetty as provided in the project.

By doing this it is hoped and expected that the periods when the entrance is good can be materially prolonged.

A survey of the entrance to the Coquille was made in September, 1891, by Mr. John R. Savage, assistant engineer.

This survey shows a governing depth on the bar of 4 feet at low water. The governing depth is constantly varying from this minimum to a depth of 10 feet at low water. The function of the jetties is to prolong the periods of greater depth as much as possible.

Amount expended during fiscal year ending June 30, 1892.—The amount expended during the fiscal year ending June 30, 1892, was $18,403.47.

Results obtained to June 30, 1892.—The results obtained at the river entrance over the condition a year ago have not been of a marked nature. The construction of the north jetty has helped to concentrate the currents upon the bar, and at times a good depth of 8 to 10 feet at low water has been prevalent. Ocean swells, however, soon occur and spread out the sands and bring the return of the ordinary bar depth of 4 to 7 feet.

Report of operations for year ending June 30, 1892.—The snagging work done during the previous fiscal year on the upper river between Coquille City and Myrtle Point has been productive of very good results—much better than was anticipated. The removal of the snags has enabled the currents to scour away the accumulated débris at the worst shoals, and this has enabled boats to run on the river continuously during the autumn, winter, and spring just passed.

The experience gained leads to the hope that if the river channel be once thoroughly cleared out, a good permanent navigable channel will result.

At the beginning of the fiscal year work was in progress extending the north jetty tramway and connecting it with Parker's Wharf and in stripping the Fahey Quarry near Randolph. At this time the tramway was 272 feet long.

All the required plant and materials were brought over from the south side, and in September, connection was finally made with Parker's Wharf by means of the tramway built across the sandy uplands on the north side of the entrance. Parker's Wharf has been materially strengthened and enlarged, and a building over the hoisting machinery was built.

At the quarry, fender piles were driven for convenience of landing and a hoisting engine and derrick put into operation. During September, 428.10 cubic yards of stone were quarried and moved to position in the jetty.

During October, 830 cubic yards of stone were added to the jetty and during November 244.32 cubic yards of stone were added.

Two small buildings were erected, one for sheltering the locomotive and one for the pile-driving machinery.

November 18, 1891, funds being practically exhausted, all work ceased and the machinery was housed. From that date to the end of the fiscal year no more active work was done upon the project. The matter of further extension of the work was studied and the country was explored for a better quarry, as the Fahey Quarry turned out to be very poor.

A number of photographic views were taken of the Coquille work, copies of which were sent to the World's Fair.

Recommendations and remarks.—A careful consideration of the con-

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dition of the work at the mouth of the Coquille led me to write the following letter:

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, February 8, 1892.

GENERAL: I have the honor to forward herewith a blue print exhibiting the latest survey of the Coquille River entrance, which shows the extent of the jetties at the present time.

This work has been done in practical conformity with the project of Maj. J. M. Wilson in 1878, at which time the cost of the completed work was estimated at $164,200.

The following are the appropriations which have been made for the work:

1880	$10,000
1882	10,000
1884	10,000
1886	20,000
1888	25,000
1890	30,000
Total	105,000

Of this amount $6,884 was expended in snagging on the Upper Coquille River, and there remains on hand at present, exclusive of outstanding liabilities, $3,700. There has been expended on the project up to the present time $94,416.

The work which has been done has been productive of great benefit, not so much by deepening the bar channel as by changing its direction from a southerly and variable course among the rocks shown on the plot to a more direct and more permanent course out to sea.

But the portions of the jetties shown on the plot are not completed in a satisfactory manner to be left with the assurance that they will be permanent.

There has never been a sufficient amount of money on hand at any one time to procure a plant suited to carry on the work properly and economically, and the design of the work and the method of carrying it on varies materially from those designs and methods which have been so successful and economical in other places where more money has been available.

I send herewith a series of photographs, which exhibit the improvements, at present existing, and their construction. The jetties are double rows of piles driven close together and surmounted by longitudinal and cross caps of heavy sawed timber. Upon these there is a single-track railway, upon which runs the revolving pile driver, and upon which are taken out the piles, rock, etc. The space between the rows of piles is filled with rock up to high water, and rock is to be dumped along the foot of the piles to give the necessary security when the piles shall be destroyed.

Photographs 167, 180, and 181 exhibit the condition of the south jetty. The outer portion of the pile tramway is in fair condition. The inner portion, built ten or twelve years ago, is nearly destroyed. The enrockment along the lagoon (the site of the old channel) has settled to about low water, and it is entirely within the realms of possibility that unless this portion of the jetty is strengthened the river may cut through this old channel. Before the work can be considered as completed this south jetty should be materially strengthened. The north jetty will require much more rock before it is finally completed.

I have made the following estimate for the permanent and thorough completion of the existing jetties, as follows:

South jetty:	
Repairs to tramway, 1,920 feet, at $2.50 per foot	$4,800
Enrockment of south jetty, 1,920 feet, at $12 per foot	23,040
Enrockment of north jetty, 530 feet, at $12 per foot	6,360
Total	34,200

Jetty extension.—The project for the improvement of the Coquille Entrance is rather indefinite as regards the length to be given the jetties. Maj. Wilson's project was for the jetties to be extended out to a depth of 12 feet in order to get a 12 foot channel over the bar. It was subsequently changed on the recommendation of Capt. Powell to an extension capable of giving a depth of 8 feet in the bar channel, he believing that this is the most that can reasonably be expected. To reach a depth of 8 feet, according to the present survey, will require an extension of the south jetty of 740 feet and an extension of the north jetty of 1,067 feet.

I have estimated that the extension of the south jetty will cost $51,090.75 and the extension of the north jetty $78,998.40.

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The total estimate for the completed project, in the light of past experience, is, therefore:

Completion of existing jetties	$34,200.00
Extension of south jetty, 740 feet	51,090.75
Extension of north jetty, 1,067 feet	78,998.40
	164,289.15
Add 10 per cent for contingencies	16,428.91
	180,718.06

In round numbers, $180,000 will be required to complete the project by extending the jetties to a depth of 8 feet at low water. The existing bar channel, shown by the survey of 1891, has a governing low-water depth of 4 feet. At times this has been increased to 8 and 10 feet.

The discrepancy between my estimate of cost and that of Maj. Wilson is due primarily to the fact that at the time the latter was made but little was known of the cost of doing work along the Oregon coast, and experience had not determined the strength and solidity required to withstand the storms of this section.

Also, there has never been an adequate amount of money to carry on the work economically, and the desire to produce beneficial results has caused the works to be extended to a greater extent than they could be fully completed, and from this has arisen the necessity for going over the work twice and three times at a large increase over what it would have cost if it had been fully and substantially completed as it progressed.

It is designed, if more money is appropriated for this project, to make a change in the plan of the work by adopting jetties more in conformity to those at Coos Bay and Yaquina Bay; that is, to build a tramway with pile bents 15 feet apart, and a jetty of brush and stone, instead of a close pile tramway with stone enrockment.

It is recommended that the estimates for the Coquille River be corrected to correspond with the figures above given.

Very respectfully, your obedient servant,

T. W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The recommendations contained in this letter were approved by the division engineer and yourself, and will be the guide in future operations.

The amounts of money appropriated for this work have always been inadequate and have resulted in greatly increasing the cost of the work.

The least appropriation which should be made for the work is $50,000, the sum recommended.

Future operations.—It is proposed to expend any future appropriation, first, in strengthening the present north and south jetties, and, second, in extending them. To this end it will be necessary to procure another quarry, and it will probably be found best to buy or build two or three scows for transportation of rock and brush.

Report of Capt. R. S. Littlefield, in charge of the work at the Coquille, is herewith.

Money statement.

July 1, 1891, balance unexpended	$21,103.49
June 30, 1892, amount expended during fiscal year	18,403.47
July 1, 1892, balance unexpended	2,700.02
July 1, 1892, outstanding liabilities	110.00
July 1, 1892, balance available	2,590.02
Amount appropriated by act approved July 13, 1892	25,000.00
Amount available for fiscal year ending June 30, 1893	27,590.02
Amount (estimated) required for completion of existing project	155,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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REPORT OF CAPT. R. S. LITTLEFIELD.

BANDON, OREGON, *June 10, 1892.*

CAPTAIN: In submitting a report of operations on the "improvement of Coquille River, Oregon," for the present fiscal year, perhaps it might be well to briefly allude to the work done prior to the commencement of this year under the same appropriation of $30,000 for the continuance of the above work, according to the act of Congress approved September 19, 1890.

This work, with the exception of snagging on the upper part of the Coquille River, to which the sum of $3,000 was applied, was preliminary to the execution of the project adopted for continuing the improvement of the entrance of the river, namely, to build a jetty on the north side whose point of starting should be Rackliffe Rock on the sea beach.

During the winter months, including March, 1891, a small force was employed in constructing twelve side-dump cars of the Yaquina pattern. During the following months, April, May, and June, the Government pile-driver was taken from near the jetty on the south side of the river to the north shore by means of a barge used at high tide, which necessitated the building of 705 feet of track approach to the barge, including track to land the driver, and to transport the same to the site for starting the new jetty.

A small submerged crib was sunk at the end of an inclined track extending 50 feet into the river; so that piles could be floated onto a car truck at the said crib landing and thence be taken over the tramway 525 feet in length to the pile-driver on the jetty. This tramway had been the route for transporting the pile-driver across the spit.

During the three months above named the jetty was built and completed as to pile driving and framing, a length seaward of 373 feet; 780 feet of track was laid and the lagoon on the south side, which formed the harbor for the transferring to the barge of the locomotive, rails, coal, and hoisting engine for the derrick, and timber formerly used, which latter was applied to the construction of the pile-driver and pile roadway across the north spit mentioned above. Also, during this time, April to June, 1891, a tramway for transporting the stone from the Parker Wharf to the connection with the inshore end of the jetty, a distance of over 3,600 feet, was graded and the rails partly laid. A considerable amount of stripping was done to develop a quarry--the prospective stone supply at Randolph, 6 miles up the river.

Three rocks in a cluster near mid-channel just inside the entrance were blown up with 600 pounds of No. 1 giant powder, and the depth over these rocks increased from 2 feet to 9 feet at low water.

The work from July to November, 1891, when the operations stopped, comprised the transfer, as needed, of the remaining parts of the plant above named from the south to the north shore of the river, the laying of the balance of the steel-rail tramway, 3,786 feet in length, connecting the jetty with Parker's Wharf; the enlargement of this wharf to double its former size; the building of a derrick on the wharf for transferring the stone from the barges to the cars; the building of a derrick at the Randolph Quarry for loading the barges, for which derrick a new hoisting engine was purchased, and the extension of the jetty 137 feet, including repairs to the same from a breach made by the sea. The total length of the jetty built by the appropriation is 510 feet.

For the whole work 771 piles were used on jetty construction; 70 at Parker's Wharf and 11 piles for a small wharf at the Randolph Quarry. The piles used at the jetty, after reaching open ocean water, were 36 feet in length. Lesser lengths, from 18 to 30 feet, were used on the beach approach, Rackliffe Rock to low-water mark.

The penetration of the piles, when the sea was reached, averaged 11½ feet, where their points struck a layer of gravel bowlders, and generally a pile could not be forced to a greater depth than the average stated, which, however, is ample for the kind of work used here, close piling, the rows of which are driven 8 feet apart outside and inside, with the piles well bonded at the top by timbers bolted to each pile.

No brush has been used on this work, as, obviously, stone can not settle below the heavy gravel bed above mentioned, the occurrence of which is exceptional; but the gravel can be found on the beaches immediately north and south.

The breach in this jetty was made where the shorter piles were used, and was caused by the seas "panning down" the beach. This happened before the track for handling the stone for the jetty was completed.

After a partial filling of the jetty was made, accretions gathered rapidly on the north side of the work to the extent that by action of the winter seas the high-water mark on both sides of the jetty advanced to within 140 feet of the end of the work, with the low water line shifting about near the end. At times a submerged spit, bare at low-water, was formed, which tailed out to sea about on line with the north jetty, and which, extended about 100 yards beyond the same. At such times during the year the bar channel was at its best, both as to directness and depth, as the channel

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line ran parallel to the south jetty and 100 to 150 feet north of the same. Throughout the year, except during parts of December, January, and February, the channel had good depths for the class of vessels employed in this trade, for which light-draft schooners are used. From the record of least soundings, as taken by the bar tug *Triumph* in sounding the bar, the channel over the same shows 6 to 7 or more feet at low water, giving at ordinary high tide 10 to 12 feet as least depths, while the usual draft, loaded, of the vessels trading from here ranges from 8 to 9½ feet. It may be stated in this connection that except when the bar is smooth no craft should draw within 3 feet of the least depth on the same, for, unlike lake harbor bars, or even those on the Atlantic coast, the seas on these Pacific bars, when rough, cause an abnormal pitching of the vessel, with the resultant effect of striking heavily on the bottom if the bar is shoal.

While the bar was in bad condition during the months named above, the southwest gales, accompanied by heavy rains, were prevalent. These heavy rains kept the river at a freshet stage, which caused the deposit, no doubt, of some of the detritus carried in suspension by the river. At any rate the conclusion has been arrived at by those engaged in commerce here that the immediate effect of a freshet is to shoal the bar, a conclusion contrary to the opinions formerly held upon this subject.

The long continuance of a full, and in consequence a rapid stream, during this season, resulted in benefit to the upper part of the river, *i. e.*, the reach between Coquille City and Myrtle Point. The steamboats plied with more regularity between these two places than for years, and the strong, steady current shortened up the three river bars obstructing navigation for a mile or so below Myrtle Point, which is the head of navigation.

The end of the south jetty, built in 1877, was disrupted by the seas and drift trees to such an extent that by March the bulkhead piles at the extreme end and 14 feet of the jetty piling were carried away.

The Coquille is exceptional to all other rivers of the coast in the amount of drift, consisting of whole trees and logs, brought down and deposited on the beaches outside the entrance. To the south of the south jetty the high-tide line receded fully 50 feet by a "panning down" process resulting from the heavy seas during storms; the low-water line moved back correspondingly.

During the year there were built: near the north jetty, a tool house; at Randolph, a quarry engine house; on Parker's Wharf, a shed over the hoisting engine, a house to store the locomotive in, and another for the protection of the pile-driving machinery.

For building the jetty tramway, wharves, houses above-mentioned, etc., 93,521 feet of new lumber was purchased and expended, and in addition there was used quite a quantity from the old tracks torn down on the south side.

The bulk of the steel rails used were on hand from a former appropriation.

There were quarried 1,501 cubic yards of stone and dumped in the jetty near the end and on both sides for nearly its full length, as riprapping.

The north jetty stands without injury, and, for the greater part of its length, sand and drift equal its height, or, in other words, the deposit formed is 17 feet above mean low water.

There are two rocks whose removal by blasting I would recommend; one just above the town of Bandon on the right-hand side of the river, and the other on the left-hand side opposite Randolph Slough, where the steamboats turn in making a landing at Randolph.

Both of these rocks are submerged, except at extreme low water, and are dangerous to navigation, being in or near the channel.

A good sized twin screw coasting steamer, the *Homer*, was built at Bandon during the present fiscal year. Tonnage, gross 433; net 330; length over all, 153 feet; beam, 32 feet 8 inches; depth of hold, 10 feet.

Mr. Adam Pershbaker has under construction at his mill a schooner for the Coquille trade, designed to carry 300,000 feet, B. M., of lumber.

Respectfully submitted.

R. S. LITTLEFIELD.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.,
(Through Mr. J. S. Polhemus, U. S. Assistant Engineer.)

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of the jetty to prevent scour. The results of the work thus far had been to keep the channel over the bar from varying its position as much as formerly and to commence an erosion of the north spit.

Instead of this erosion continuing as expected, the water broke through the spit in a swash channel, thus greatly reducing the effectiveness of the currents on the bar.

I quote the following from my last annual report as to the results obtained to June 30, 1891:

There has been practically no change in the results since the preceding annual report.

There has been considerable trouble with the bar, during the past year, owing to the waters spreading out in an uncontrolled way and the prevalence of storms which repeatedly filled with sand the bar channel made by the ebbing and flooding waters.

The erosion of the north spit went on during the year, and a better direction for the outflowing and incoming currents has been thus secured. The troublesome cross currents and eddies which formerly prevailed inside the bay, due to the meeting of the waters of the main and south bays, have practically disappeared.

The bar has sometimes had a good depth of 12 to 15 feet at low water, and at other times has shoaled to about an equal depth at high water. The works which have been done have not increased the bar depths, and no increased depth can be expected until the north jetty, now under construction, has been very considerably extended.

Amount expended during fiscal year ending June 30, 1892.—The amount expended during the fiscal year ending June 30, 1892, was $62,161.43.

Results obtained to June 30, 1892.—The north jetty and approach has been built to a total length of 4,800 feet from the wharf located on the inside of the north spit near its end. Of this length 1,808 feet is beyond the low-water mark, 1,392 feet is between high and low water, and 1,600 feet above the ordinary high-water mark, as high and low water existed at the time the work was commenced.

As a result due to this extension, or due to this and other causes, there has been a marked improvement in the entrance to Coos Bay during the past winter. Reports were constant during the winter that the bar depths were from 18 to 21 feet at low water. In order to learn the exact condition of the bar a survey was made during March, 1892, and the platted results show the bar some 2,000 feet inside the location of the bar at the time of the survey in August, 1891, and a channel over the bar with 18 feet of water on it at low water. This bar channel is a little to the north of the bar channel existing the previous summer and has been in continual existence for about eight months.

The exceptionally great results from the small amount of work done is explained by the fact that the jetty cut off the swash channel across the north spit directly opposite Fossil Point, throwing a large part of the ebbing waters over against Coos Head, and thus tending to concentrate the waters upon the bar. It is not expected to maintain the depth shown by the present extension of the jetty at all times during the summer.

Report of operations.—At the beginning of the fiscal year the jetty tramway had been built to a length of 1,600 feet. The work of building it was in progress and continued uninterruptedly until October 1, 1891, at which date there had been completed 303 trestle bents, or 4,800 feet. One thousand eight hundred and eight feet was built beyond the line of low water.

The work has been done by day's labor, with material furnished by contract.

A contract was entered into with Mr. Patrick O'Neil for furnishing brush fascines (1,000 cords, more or less) at $2 per cord. The first load of fascines was received from him August 22, and he completed his

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contract in January, having furnished 1,158¼ cords, while on account of delay on his part 368¼ cords were procured by hired labor.

Contracts were entered into with George W. Loggie for furnishing poles (2,000, more or less) at 22 cents each, and with Mr. William E. Baines for quarrying and delivering rock (20,000 tons, more or less) at 75 cents per ton.

The work of making mattresses and dumping rock was begun August 27, 1892.

By the middle of December mattress work ceased for the season, and at that time the brush work consisted of—

	Feet.
Center mattresses from Bent 103 to 303	3,200
Second-tier mattresses from Bent 100 seaward	160
Inside mattresses on bay side from Bent 60 to 103	592
Side mattresses on sea side from Bent 140 to 164	384

Six spur mattresses 20 feet square.

Considerable trouble was experienced in getting rock fast enough from Contractor Baines, but by the end of December the crest of the enrockment had reached half tide, and by the middle of March it had reached ordinary high tide. The cost of unloading and dumping rock was found to average 8 cents per ton. During the year 23,923.4 tons were dumped on the jetty.

Employés were subsisted at the Government mess house while operations were being carried on.

The cost of feeding employés per day per man at north spit was found to be 36.9 cents.

Much miscellaneous work was done during the year, such as building a storage platform, gridiron for brush and piles, constructing an additional scow, building a locomotive house and trestle sidings, assembling the last 12 cars of the 20 sent from Fort Stevens, overhauling and repairing cars, etc. A small dwelling house for the superintendent in charge of the work has also been constructed.

Reclamation of sand dunes.—As stated in my last annual report, a quantity of Holland grass roots was received from San Francisco and planted in several localities on the north spit.

About one-third of the roots sprouted, and give promise of a vigorous growth.

During April, 1892, another consignment of 100 sacks of roots was received, and these have been set out on the north spit.

A wire fence has been built across the spit to keep cattle from the lower portion of it, and during March, 1892, about 80 bushels of oats, barley, and mixed grass seeds were sown.

About 600 young pine and spruce trees were dug up and transplanted to the north spit.

From Fort Stevens we secured a quantity of Scotch broom seed, which was planted early in the spring of 1892.

There was also gathered a large quantity of the seeds of plants growing naturally about the locality. These consisted of marine pine cones, killikinick berries, salal berries, and other plants, the names of which are not known. These were all planted, both as mixtures and separately. The knowledge gained by these experiments will be valuable in the further prosecution of the work of the reclamation of the sand flats.

Survey.—A survey of the bar was made in March, 1892. For this purpose the tug *Hunter* was secured. This survey was made by Mr. John R. Savage, assistant engineer.

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The results of the survey were submitted in April, 1892. Mr. Savage's report on the survey is herewith:

PORTLAND, *Oregon, May 9, 1892.*

CAPTAIN: In obedience to your instructions I left Portland March 3, 1892, on the steamer *Willapa*, and reached Coos Bay the following day.

After consultation with Mr. J. S. Polhemus, who acted in conjunction with me in making this survey, the powerful bar tug *Hunter*, Magee, captain, was engaged for our use at a compensation of $30 per day of actual use.

While it was much more convenient and agreeable when sounding to be on a large, strong boat like the *Hunter*, there was at the same time the necessity to keep in water over 15 feet in depth, as the draft of the *Hunter* was between 10 and 11 feet, hence it was impossible to develop the spits to any extent.

Since the last survey of the bar, in August, 1891, the channel over the bar has lost its fan shape, and has narrowed considerably and moved very much to the northward, and has deepened as well to a depth of about 23 feet at high water.

The swash channel skirting the south end of the sand spit, as shown on the map of the survey of August, 1891, has been shut off by the extension of the jetty, and the sand has begun to fill up behind that portion of the jetty where the old swash channel formerly was, and in fact behind the whole extent of jetty construction.

Another channel of very much the same nature as the above has made out past the present end of the jetty, with an average depth of 3 or 4 feet at low water, and a width of about 1,000 feet at the same stage of tide, and when it is smooth on the bar, there is at high water what looks like a good channel out to sea through this new swash channel. The scouring effects of the tides as they flow past the present end of the jetty is shown in a very marked degree by the depth of water a little beyond the end of the jetty, where there was something over 25 feet at low water.

In dark or foggy weather this portion of the bar is very deceptive, and in one instance, at least, has been taken for the regular channel over the bar. This was the case with the steam schooner *Emily*, which came into Coos Bay via this swash channel some time this spring, but it took her nearly three or four days to get across the sands, and she was in a bad condition when she got in, as may be imagined.

In this swash channel the tides begin to flood from one-half to a whole hour sooner than in the main channel, at least the surface currents run in there before they do in the main channel.

For five or six days subsequently to my arrival in Empire City the weather was foggy and thick, and the water rough during the mornings, when the tide was flooding; but some of the beacons required attention, and we located the low-water lines on the sand spit as far as possible, as well as the present end of the jetty, nearly all of which was done by sextant observations. In all about 4.3 miles of low-water line were located. The shifting character of these sand spits is very easily understood when once a person has walked upon them, for the sand affords a very uncertain footing, as it is practically all afloat, and one has to be constantly on the move or else he is likely to sink down considerably further than is consistent with comfort.

On the 10th, 11th, and 12th of March, the weather was good and the bar very smooth, and on these days on the flood tide, we were sounding on the bar, and while the tide was ebbing we sounded outside the bar with the idea of determining if any change had taken place in these depths outside. These lines run outside the bar were pretty well apart, but suffice to show how very little change had taken place since the last outside survey in 1885. The outside contours had then practically the same position as now, but the contours in near the bar have moved out about 1,000 feet since then.

Since the last survey of the bar in August, 1891, the channel has improved considerable as to depth, but there is no longer the straight course out to sea that there was in 1891. Now, the channel extends from Coos Head past Guano Rock, out toward the bar buoy, but before reaching the latter swings off to the northward, and then again more to the westward and over the bar. There is now about 9 feet more water over the bar than in August, 1891, as it is now possible to carry a least depth of 18 feet at mean lower low water out to sea. It was extremely fortunate that there were such favorable conditions for making this survey of the bar, as for months previously and weeks subsequently, it would have been impossible to have sounded the bar channel, on account of the roughness of the sea.

We set out a number of floats at various times, but mainly on the ebb tide, as that was the most convenient time, as we always took advantage of every minute possible of the flood to sound the bar. When the floats were started in on the ebb tide in the channel they moved at an average rate of about 4 miles an hour for about 2,000 feet on each side of the bar, but their rate of speed was decreased as they got further and further away from the bar. The great mass of the water passing out on the ebb tide would seem to be unaffected by any littoral current until about a mile out beyond the bar when it begins to be deflected to the north or the south, accord-

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ing to the direction in which the littoral current is moving. There were a number of floats put in a couple of thousand feet outside the bar on a flood tide, and they worked in toward the bar very slowly, not averaging 1,000 feet per hour, even with a slight wind from the northwest, and as the tide changed, they began to work south outside the bar, with very little increase in velocity, toward the inside of Yokam Point.

Subsequently three other floats were tried on the ebb from well inside of Coos ead, and as a result of observing them, I should judge that the amount of water Hassing out over the spits was not very great in comparison with the amount passpng out the channel. One float was put in well toward the end of the jetty and iwent out directly over the north spit, while the other two, being more in the main channel, followed the same well out beyond Guano Rock, when one of them being more to the south, began to be drawn toward the south spit, and finally passed out to sea over that spit, while the other followed the main channel for awhile and then slipped out to the north of the bar buoy.

On the ebb tide there is a very noticeable and interesting tide rip, as the current on the bar proper must run at the rate of 5 miles per hour, or perhaps faster, which, combined with the swell rolling in, makes an extremely rough-looking bar, on which, however, there is really only a bad chop sea, but to anyone who did not know the channel from ranges on shore, it would be impossible to pick it out at such a time, on account of the nasty looking and ever-changing seas on the bar.

While the tide is running out this way the whole mass of water is seen to carry sand in great quantities, which is probably deposited in the smoother water a short distance beyond the bar, as soundings show 2 or 3 feet less water just outside the bar, if taken on an ebb tide instead of on the flood.

I was told that frequently the greatest current runs directly under Coos Head, but during this survey the water seemed to have a greater velocity upon the bar.

The littoral currents would seem to be directly affected by the wind and its changes, and during the summer months when the wind is from the northwest the general trend of the current is southerly, and in winter with the prevailing southerly winds the current is nearly always moving to the north.

I had several conversations with the men on the bar tugs and with Capt. James Magee, of the *Hunter*, in particular, as I know he is a very observant man and one on whose word and judgment reliance can be placed. All the bar men are unanimous in their opinions in regard to the action of the winds upon the littoral currents and their general directions, but they notice very little of a littoral current in near the bar, but it is always noticeable at the whistling buoy where the current often runs from 1 to 2 miles per hour. This alongshore current is usually perceptible from one-fourth to 15 miles offshore and its direction, at least on the surface, usually shifts with a change of wind, and oftentimes before the wind changes, in the same way, that the direction of the swell will change before the wind shifts.

At times a slight eddy has been noticeable in near the bar with a direction opposite to that of the main littoral current. The presence of this eddy, or of so slight a littoral current in near the bar is due, I think, to the fact of the proximity of Cape Gregory, which helps to form the small bay in which the entrance to Coos Bay is situated.

At the time of this survey the prevailing winds were about shifting from the southwest to the northwest, and one day the littoral current would be in one direction, and the next day perhaps running exactly opposite, on account presumably of the wind shifting. As an example, on Thursday, March 10, out at the whistling buoy there was a strong northerly current with the wind blowing strongly from the southwest, from which there was quite a heavy swell noticeable outside the protection of Cape Gregory, while on the following day, Friday, there was a rather strong southerly current with the sea very smooth indeed, and practically no wind, what little there was coming from the northwest. On Saturday the conditions were very much the same as on Friday, only with less current and a little more wind.

Capt. Magee, of the tug *Hunter*, states that the best water and safest channel is always found when the channel across the bar is in its most southern position, *i. e.*, about 500 or 1,000 feet south of the present position of the bar buoy. It is safest because it affords the shortest and most direct route out to the sea, and enables a vessel generally to take the swell head on, or nearly so. At one time, when the channel was in the above position, there were 27 feet at low water across the bar.

It would have been inconvenient to have plotted the lines as we ran, on account of the lack of a reliable recorder and proper drafting facilities, etc., on board the *Hunter*. I did most of the recording myself, and Mr. Polhemus and Morton L. Tower read the sextants during this survey. The leading was done by the deckhand of the *Hunter*, who proved quite competent.

Very respectfully, your obedient servant,

J. R. SAVAGE.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

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Recommendations and remarks.—The work already done, under the present project at Coos Bay, has produced such fine results that the belief is encouraged that for a sum of money, considerably less than the estimated cost, the entrance to the bay can be improved to the extent specified in the report of the Board of Engineers of 1888.

During the past year, owing to the general depression of business all over the Pacific Coast, the commerce has not shown much increase, but a great deal of attention has been bestowed upon the great coal fields of this section, and it is believed that soon several of these will be opened and the coal shipped to the markets of the world.

In prosecuting works of this kind it is desirable to remember that a considerable portion of the auxiliary construction and plant is of a perishable nature, such as the pile tramway, wharves, scows, etc., and that economy dictates that once commenced the work should be prosecuted to completion before the final destruction of these perishable portions.

At Coos Bay a very excellent plant is on hand and every facility for pushing the work. In order to carry on the work with the utmost vigor and economy an appropriation of $500,000 is recommended for the next fiscal year.

Future operations.—With any money which may become available under new appropriations it is expected to push the work of extending the north jetty as rapidly as possible.

The report of Mr. J. S. Polhemus, engineer in direct personal charge of the work, is herewith.

Money statement.

July 1, 1891, balance unexpended		$68,909.52
Amounts expended by Treasury Department	$285.26	
June 30, 1892, amount expended during fiscal year	61,876.17	
		62,161.43
July 1, 1892, balance unexpended		6,748.09
July 1, 1892, outstanding liabilities		950.00
July 1, 1892, balance available		5,798.09
Amount appropriated by act approved July 13, 1892		210,000.00
Amount available for fiscal year ending June 30, 1893		215,798.09
Amount (estimated) required for completion of existing project		2,131,412.20
Amount that can be profitably expended in fiscal year ending June 30, 1894		500,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. J. S. POLHEMUS, ASSISTANT ENGINEER.

EMPIRE CITY, OREGON, *June 15, 1892.*

CAPTAIN: I have the honor to submit the following report of operations on the work under your charge of improving the entrance to Coos Bay, Oregon, for the fiscal year ending June 30, 1892.

At the date of the last annual report, June 30, 1891, we had nearly completed the installment of the working plant. The wharf and buildings for quarters and shops were finished. The hoisting engine and wharf derrick were being used. The 11-ton Baldwin locomotive was at work hauling materials of construction, and the large revolving jetty pile-driver, received in pieces from the work at the mouth of the Columbia River, had been assembled and was nearly ready to be used extending the tramway.

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The shore portion of the jetty tramway had been extended nearly 1,600 feet from the receiving wharf. Only four of the geared dump cars had been received from Fort Stevens.

During the past fiscal year operations at Coos Bay consisted chiefly in continuing the work already begun with the $125,000 appropriated September 19, 1890, of which the available balance was something over $56,000.

It was the extension of the north jetty under the general plans approved by the Board of United States Engineers October 27, 1889. From 30 to 40 men were employed at the spit, and the jetty as completed consists of a ridge of pieces of rock dumped on a foundation mattress of brush fascines 20 feet wide. Its crest is brought up to ordinary high-tide level, and the enrockment takes such slopes as the surges naturally produce, being about 2 to 1. The mattress is laid and the rock dumped from a double-track pile-trestle tramway, constructed in advance by an overhang revolving pile-driver. Early in July the last of the four large scows for transporting the stone was completed. In the same month we finished the gridiron for brush, 50 feet by 400 feet, and a coal bunker 12 feet by 30 feet. Also a trestle spur track about 300 feet long to accommodate cars not in use. Finding our car shop not large enough for the work, we extended it into the locomotive house, and erected another building for the latter 20 feet by 30 feet.

Extension of jetty tramway.—As before stated, at the commencement of the fiscal year, the tramway had reached a point about 1,600 feet from the receiving wharf. It consists of a double track, 3-foot gauge railway, 13 feet from center to center between tracks, resting on longitudinal stringers of fir 12 by 16 inches by 32 feet, supported on four pile bents 16 feet apart, capped with fir timbers 12 by 12 inches by 22 feet. Two 3 by 12 inch planks are placed between the tracks for footwalks.

The track runs level from the wharf, and the elevation of top of rail is 21½ feet above the plane of mean lower low water.

The tramway was extended by means of the large jetty pile-driver with its 10 by 6 by 10 inch Worthington steam pump and water jets. It is the same driver with which the greater part of the jetty tramway at the mouth of the Columbia River was built, and a good general description of the machine and its working is given in Mr. Hegardt's report to Maj. Handbury on page 3021, Report of Chief of Engineers, 1890, except that our machine has only single trucks of a somewhat different pattern. It proved an efficient machine in this locality.

The piles used were of fir from 45 to 56 feet long and about 17 inches in diameter at butt, and cost 4½ cents per foot. They were pumped into the sand from 20 to 27 feet. The hydraulic jets were supplied by means of a 10 by 6 by 10 inch Worthington duplex steam pump, with hose connection attached to two 1½-inch pipes temporarily secured to each pile with staples.

These pipes were drawn up when the pile top had reached a point within a few inches of its required elevation, and it was then driven to grade by a few blows of the hammer, thus obviating the necessity of sawing it off.

The piles, lumber, and rails were run out to the driver from the storage platforms on ordinary flat cars. Up to the present time we have not found it necessary to use sway braces on the trestle, but in future this will be required.

The pile-driver crew, including those employed preparing and loading piles and lumber, consisted of eleven men with daily wages amounting to $29.50.

After the surf was reached the average daily extension was four bents, or 64 feet of completed tramway. The greatest day's work was five bents, and during the month of September a total tramway extension of 1,280 feet was accomplished, although we did not work continuously on account of the weather.

The actual cost for one 16-foot bent of tramway, being the average of the season, is as follows:

1,384 feet B. M. lumber at $9.50	$13.15
4 50-foot piles, 200 feet at 5 cents	10.00
640 pounds steel rail at $50 per ton	16.00
2 rail joints	85
11 pounds railroad spikes at 3.6 cents	40
60 pounds drift bolts at 3 cents	1.80
Labor (average season)	9.83
Total cost one bent	*52.03
Cost per running foot	3.25

From the wharf, the first 1,600 feet of tramway is located above extreme high-water mark; the next 1,392 feet is between extreme high water and ordinary low water. Immediately after passing low-water mark, a small swash channel was crossed about 500 feet wide and from 6 to 8 feet deep at low tide. Beyond this channel on the

* No allowance is made for first cost of plant.

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jetty line, the sand spit was swash at low tide except toward the jetty's present outer end, where the depth was from 4 to 6 feet at low tide. (See profile of jetty forwarded to you in February last.

The tramway from a point about 1,335 feet from the wharf is on a curve with a radius of 3,400 feet.

We commenced to use the jetty pile-driver July 15, and stopped driving piles and hauled it in October 1, 1891.

The total extension is 303 bents, mostly 16 feet apart, or about 4,800 feet from the receiving wharf on the bay channel, of which the outer 1,808 feet is beyond where the low water was at the beginning of operations. All tramway work, as well as the making of the brush mattresses and dumping the rock, was done by hired labor.

Brush mattress work.—A center brush mattress 20 feet wide and 3 feet thick was placed on the sand about the piles, from bent 103 to the sea end, a distance of 3,200 feet.

Where it could not be built directly on the sand, it was made on a grillage of poles suspended by ropes fastened to iron hooks from the tramway and lowered into place, and quickly sunk by a few car loads of the smaller-sized rock.

The mattresses are made by binding with rope, or wire, three courses of brush fascines, 20 feet long by about 1 foot in diameter, between grillages of fir poles crossed every 4 feet, the latter being 7 inches in diameter at butt and 24 feet long.

The fascines were of fir, cedar, or hemlock brush, choked and bound with 4 ties of 3-ply bale rope. Old rope and No. 12 annealed wire were used for the main lashings.

The poles and fascines were mostly obtained by contract.

The poles from Mr. G. W. Loggie, at 22 cents apiece on scow at Catching Slough. It cost 7 cents apiece to deliver them at the works, and about 2 cents apiece more to unload them and store them.

We received in all 2,353 poles, and have about 100 left on hand.

Mr. Patrick O'Neil had the brush contract at $2 per cord on scows at various points on the bay, which we had to tow to the works. He furnished 1,157 cords.

It cost about 30 cents a cord more to tow the brush to the north spit, and about 18 cents to unload and place it on the gridiron.

On account of slowness of delivery, we increased our supply by hired labor, getting 366 cords from the thickets about Empire City at a cost of a little less than $2 per cord on scows.

We used altogether 1,523 cords, including about 100 cords left on the gridiron.

In addition to the regular center mattress laid throughout the outer 3,200 feet of jetty, a double mattress was placed for 160 feet between bents 100 and 110, where the jetty crossed the deepest part of the swash channel. Side mattresses were placed on the west of the jetty for 384 feet, and on the east or the bay side between bents 66 and 103, a distance of 592 feet.

The cost per running foot of mattress 20 feet wide and 3 feet thick was $1.24.

It will probably be necessary to lay side mattresses on future jetty extension.

Stone supply.—The stone was supplied under contract with Mr. William E. Baines, of Marshfield, who quarried and delivered it on board Government scows at the north spit for 75 cents per ton of 2,000 pounds, the stone being measured by water displacement of scows.

He was allowed to obtain the stone from the Government quarry on the North Fork of Coos River, about 23 miles from the works.

The stone is a moderately soft sandstone with a specific gravity of about 2.25.

He used the steamer *Express* at first to tow the scows, but after she was burned at Marshfield the steamer *Antelope*, a small propeller with a 10 by 12 inch engine, was substituted.

He commenced delivery August 24, 1891, and towed down the last load April 5, 1892. He supplied 100 scow loads, equal to 23,923 tons.

The pieces of rock averaged 2 tons, and about one-fourth of it 4 tons.

It cost us 8 cents to unload and dump it on the jetty, not including cost of plant. It was nearly all dumped in the middle between the tracks, and made an enrockment on the center mattress from bent 103 to the sea end, a distance of 3,200 feet, of which the outer 1,800 feet was beyond low-water mark.

The elevation of crest of dump was not below ordinary high-water level at the close of the work. Only one derrick was used on the wharf, operated by a double cylinder 10 by 12 inch Lidgerwood hoisting engine and ¾-inch diameter steel-wire rope.

A single 11-ton locomotive and 20 geared dump cars and 4 flat cars were used. With this rig we could unload a scow load of 250 tons in six to eight hours.

We used Coos Bay coal at $3 per ton as fuel for the locomotive and driftwood cut up for the hoisting engine.

The train crew consisted of one engine-driver and one brakeman, who also dumped the cars.

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Five men worked on the scows and four on the wharf, including engineer of hoisting engine.

Eight scow loads of the poorer rock were dumped on the side mattresses on the bay or east side of tramway for 592 feet between bents 66 and 103 to prevent the threatened encroachment of the bay channel at this place.

Close of active operations.—Active operations closed soon after the delivery of stone ceased for want of sufficient funds to continue purchase, about the middle of April. The four stone scows were moored alongside the boom at Yarrow, away from the influence of the teredo, and the sheathing taken from their decks. The pile-driver was housed on the turn-out prepared for it, the locomotive and hoisting engines painted and oiled, and the smaller tools and appliances put away.

Reclamation of sand dunes.—With a view to the future work of reclaiming the dunes of the north spit, to prevent the winds from carrying the sand into the bay, some experimental work was done to ascertain the most suitable plant growths and the most advisable time of the year for planting.

Thirty sacks of Holland grass roots were obtained from the Golden Gate Park commissioners, of San Francisco, and set out in the sands here April 30, over a year ago. We planted about 3 acres with it, but only one quarter of it lived; but I notice that which survived has commenced to spread and grow.

This spring we received 100 sacks of the same kind of grass roots, and set it out about a month earlier, planting 5 or 6 acres. We set the small bunches of roots about 14 inches deep in the sand and 2 or 3 feet apart. Up to date nearly every bunch appears to be growing well, and I believe it is the most suitable growth to start this work with.

Last fall we gathered about 10 bushels of seeds of plants native to the spit, and 30 bushels of Marine pine and spruce cones, and shook out and planted the seeds this spring. We also planted 50 bushels of oats, 25 bushels of barley, and 5 bushels of assorted grass seed.

Severe storms continued late this spring, and I fear most of the oats and barley is destroyed.

We also planted a sack of Scotch broom and other seeds, and transplanted 400 small Marine pine and spruce trees, and set out a number of willow cuttings.

The exposed spit is a very difficult place to get any growth started, and from present experience I think the Holland grass is the best to begin with, supplemented with seeds of native plants and Marine pine.

It will probably be necessary to cover the higher dunes with a protection of brush until the plant life gets started. We built a barb wire fence one-third of a mile long across the spit from bay to ocean to prevent cattle from straying down and interfering with the grass plantations.

Towing.—According to our contract with Mr. Baines, we were entitled to the use of his boat when she was not employed in towing the rock scows. Although we got some work out of the boat in this way, we were obliged to hire considerable extra towing to transport the brush, poles, piles, coal, etc. We employed the local boats for this purpose at an agreed price per trip. We often experienced delays and found this method inconvenient, and I would recommend for another appropriation the charter or purchase of a good-sized steam launch to tend on the works, tow small scows and piles, and deliver supplies.

Water supply.—The large and shallow well in the sands of the north spit furnished a copious supply of fresh water at the works. It was pumped into an elevated tank by an 8-foot Aeromotor windmill.

Plant.—We received from the Government works at Fort Stevens 20 geared dump cars, which came knocked down for ease in shipment. These we assembled at the jetty.

We have on hand now the following plant, all in good order: Four large stone scows, described in last Annual Report; one small scow 40 by 14 by 4; one 11-ton trailing truck Baldwin locomotive; twenty geared dump cars (Fort Stevens pattern); four flat cars; two mattress cars; four push cars; one jetty pile-driver; one double-cylinder 10 by 12 Lidgerwood hoisting engine; one small hoisting engine; an outfit of small boats, oars, pumps, blacksmith tools, saws, sledges, axes, hose, stoves, and other small tools and appliances.

Results accomplished and changes effected to date.—Immediately after the extension of the north jetty across the swash channel the sands on the sea side began to accumulate and have built up above low-water level nearly to its end. At the same time the extremity of the north spit commenced to cut away along its southern and eastern edge, widening and straightening the channel. In October the depth on the bar began to rapidly improve.

Whereas for the year previous the least depth at mean low water in the bar channel had been about 10 or 11 feet, as soon as the jetty was extended to its present length it attained a depth varying from 16 to 18 feet at the same stage of tide, which has been maintained ever since for a period of eight months.

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A survey of the bar was made last March, which shows 18 feet at mean low water.

Miscellaneous.—While the work was in progress last fall a set of photographic views was taken by Mr. Bratt, illustrating the manner of construction.

A careful record of the commercial statistics for the port of Coos Bay has been kept for the past fiscal year and forwarded to you monthly.

A survey of quarry sites on Coos River was finished, and a small dwelling for use of overseer is now being built.

Very respectfully, your obedient servant,

J. S. POLHEMUS,
Assistant Engineer.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Coos Bay is in the collection district of southern Oregon. Empire City, on the bay, is the port of entry. The nearest light-house is at Cape Arago, on the south side and west of the entrance.

The following returns are furnished by Mr. J. S. Polhemus, assistant engineer in charge of works at Coos Bay, and are for the fiscal year ending June 30, 1892:

Arrivals and departures of vessels.

	Number.	Aggregate tonnage.
Arrivals	349	76,729
Departures	345	76,459
Total	694	153,188

Vessels built.

Schooner *Volante*	net tons	98.51
Schooner *Nonoma La Paz*	do	57.38
Steam launch *Fawn*	do	7
Schooner *Bowhead* (rebuilt from old tug *Columbia*)	do	103
Number of passengers arrived by sea		1,358
Number of passengers departed by sea		1,689

No new routes of travel have been established on the bay since date of last annual report.

Article.		Quantity.
Exports.		
Lumber	feet B. M.	40,805,537
	tons	81,105
Laths	number	5,814,500
	tons	1,453
Broom handles	tons	11
Spruce staves	number	3,126,444
Skip knees	do	193
Coal	tons	36,183
Matchwood	cords	2,074
	tons	5,309
Piles	number	203
	tons	142
Chittim bark	tons	36
Salmon:		
Canned	do	67.9
Salt	do	33
Apples	do	76.5
Pears	do	.2
Potatoes	do	216.9
Cheese	do	6.1
Eggs	dozen	1,050
Butter	tons	14.3
Hides and leather	do	5.2
Borax	do	75
Miscellaneous freight	do	4,499
Pickets	do	74.7
Barrel heads	number	144,442
Barrel hoops	do	160,000
Spars	do	26
Machinery, etc	tons	70
Railroad ties	do	165
Chickens	dozen	37
Redwood boxes	number	10,000
Specie, $3,776		.....
Total	tons	129,542.8
Imports.		
General merchandise and machinery, $376,000	tons	7,522.7
Specie, $41,254.88		.....
Total	tons	7,522.7

Estimated value:

Imports	$417,254.88
Exports	1,338,446.00

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IMPROVEMENT OF UMPQUA RIVER, OREGON.

Description of original condition.—Just below Scottsburg, the head of navigation on the Umpqua River, are five sandstone bars or ledges 12 to 15 feet wide and submerged from 1 foot to 2 feet at low tide on a low-river stage. They are separated by pools about 150 feet wide and from 5 to 10 feet deep at low water.

Plan of improvement.—The honorable Secretary of War having authorized the expenditure of the balance remaining of the appropriation of March 3, 1871, viz, $4,685.89 in improving the river below Scottsburg, a project was submitted and approved in 1885 for making at an estimated cost of $4,056, a channel 50 feet wide and 3 feet deep at low water through the rock ledges above described, by drilling and blasting the rock and removing the broken pieces to deeper water in the pools.

In September, 1889, a survey was made of the Umpqua River from Scottsburg to its mouth, and a project prepared for its improvement which was submitted January 16, 1890. This project provides for the removal of rock bowlders and ledges in the wharf basin at Scottsburg, and below this basin with the view of opening a channel way 50 feet in width and 4 feet in depth at low water. The project was approved under date of October 28, 1890.

The estimated cost of completing the project was $9,000.

APPROPRIATIONS.

Act of—	
March 3, 1871	$22,500
August 11, 1888	2,000
September 19, 1890	9,000
Total	33,500

Amount expended to June 30, 1891.—The amount expended on the project to June 30, 1891, was $3,992.42.

Results obtained to June 30, 1891.—The result obtained was a navigable channel 50 feet wide and 2 feet deep at low water, extending nearly through the reefs below Scottsburg, where formerly there was only a foot or less in depth.

Amount expended during fiscal year ending June 30, 1892.—The amount expended during fiscal year ending June 30, 1892, was $7,252.74.

Results obtained to June 30, 1892.—The project was nearly completed. Before it could be entirely completed, however, the water in the river rose and became muddy, so that the finishing touches could not be given. There are in consequence some points of rock which will have to be removed before the project can be considered as fully completed.

Report of operations.—Mr. C. M. Carlson was placed in charge of the works of rock removal on the Umpqua. This work commenced in July, 1891, and continued until November, 1891.

During this time, 955 tons of rock were blasted, hoisted, and loaded on a scow and removed to a convenient locality where it could be dumped without injury to navigation.

Holes were drilled by means of an Ingersoll steam drill. They were then loaded with dynamite and exploded by fuse and sympathetic detonation.

The rock broken was raised by means of a diver and a steam hoisting engine and dumped by hand.

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Recommendations and remarks.—It is believed that sufficient money is on hand to complete the project, and therefore no recommendation for further appropriation is made.

Future operations.—As soon as practicable the work of completing the rock removal from the selected channel will be commenced.

Money statement.

July 1, 1891, balance unexpended	$8,693.47
Amount refunded February 9, 1892	2.55
	8,696.02
June 30, 1892, amount expended during fiscal year	7,252.74
July 1, 1892, balance unexpended	1,443.28

COMMERCIAL STATISTICS.

Umpqua River is in the collection district of Southern Oregon. Empire City, on Coos Bay, is the nearest port of entry. The nearest light-house is at Cape Arago, entrance to Coos Bay, distance 22 miles.

The following returns, furnished by Mr. O. B. Hinsdale, of Gardiner, Oregon, are for the year ending June 30, 1892:

VESSELS ARRIVED AND CLEARED.

The number of vessels of all descriptions crossing in over the Umpqua River Bar during the year was 16; the number crossing out was 16. Their names, registered tonnage, and draft, are as follows:

Name.	Trips.	Registered tonnage.	Draft loaded.
			Ft. in.
Schooner J. B. Leeds	8	217.70	13 4
Schooner Una	8	197.22	14 0
Schooner Lily	11	135.40	12 0
Steamer Pasadena	1	235.56	13 6
Steamer George H. Chance	6	71.17	9 0
Steamer W. H. Harrison	1	70.00	6 9
U. S. S. S. Manzanita	1	451.84	10 6
Schooner Sadie	5	295.00	13 6
Schooner Lucy	8	294.00	13 6
Schooner Beulah	4	339.14	14 8
Schooner Zampa	1	366.48	15 0
Schooner Webfoot	1	343.69	15 0
Schooner Ivy	1	135.40	12 0
Tug Hunter	20	52.25	9 0
Tug Liberty	20	.....	7 0
Tug Printer	2	55.38	9 0

There were no vessels built here during the year, and no new routes of travel established.

River traffic.

Steamer *Juno* (propeller), 22.28 registered tonnage:

Miles run during year	8,500
Passengers carried during year	2,470
Freight carried during year ... tons	750

Steamer *Restless* (stern-wheeler), 101.02 registered tonnage:

Miles run during the year	5,000
Passengers carried during the year	1,357
Freight carried during the year ... tons	1,025

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Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
Exports.			*Exports.*		
Lumber, feet, B. M	12,142,000	.....	Hides and furs....tons..	3	750
Lumber.....tons..	24,284	$194,272	Grain.....do...	234	5,850
Laths.....do...	733	7,335	Hops.....do...	3	1,050
Butter.....do...	2	1,000			
Wool.....do...	16	6,400	*Imports.*		
Leather.....do...	5	3,000			
Apples.....do...	5	100	General mdse.....tons..	1,880	150,000

Total exports (tons, 25,285½) $219,757
Total imports (tons, 1,880) 150,000
No salmon exported, as cannery did not run this year.

T T 4.

IMPROVEMENT OF MOUTH OF SIUSLAW RIVER, OREGON.

Description of original condition.—The Siuslaw River enters the ocean in the midst of a vast shifting sandy beach, without any headland or fixed point to determine or aid in determining the location of the entrance channel.

The unconfined channel has a range of about 1 mile, over which it wanders in making connection with the ocean. In consequence of this wandering and spreading out of the outgoing and incoming waters, the bar at times shoals very badly, while at other times it has a depth equal to the controlling depth inside the entrance. The depth on the bar varies from 5 to 12 feet at low water, and the bar channel changes very much in position and direction.

At times a channel is developed inside the bar which runs nearly parallel with the coast. This channel is narrow, badly defined, and dangerous, as boats have to pass through it in the trough of the sea.

At other times there are two channels.

Plan of improvement.—The plan of improvement for the entrance to the Siuslaw is to confine the outgoing and incoming waters between high-tide stone jetties, so located as to direct the currents upon the ocean bar in a direction practically perpendicular to the coast, these jetties to converge till they are 600 feet apart at the crest of the bar.

The location of the jetties is approximately shown upon the map published with the last annual report from this office. (Report of Chief of Engineers, page 3178.)

The north jetty leaves the mainland about half a mile north of Cannery Hill and is 4,500 feet long. The south jetty extends from the end of the sandy peninsula and is 3,200 feet long.

The wharf for the north jetty is located just below Cannery Hill, and the approach to the jetty is 3,000 feet long.

The wharf for the south jetty is opposite the north jetty wharf, and the approach is 2,400 feet long.

The jetties are to be built of brush and stone from a pile tramway.

APPROPRIATION.

Act of September 19, 1890 ..... $50,000

Amount expended to June 30, 1891.—The amount expended during the fiscal year ending June 30, 1891, was $601.96.

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Results obtained to June 30, 1891.—No work was done and no results obtained.

Amount expended during fiscal year ending June 30, 1892.—The amount expended during the fiscal year ending June 30, 1892, was $29,816.90.

Results obtained to June 30, 1892.—The work has been entirely of a preliminary character and nothing has been done which could have any effect on the entrance to the river, and consequently no results have been obtained.

Report of operations.—The report of the Board of Engineers, published in my last annual report (page 3175, Report of Chief of Engineers), was approved August 4, 1891, by the Chief of Engineers.

The following is the indorsement on the report:

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
August 4, 1891.

Respectfully submitted to the Secretary of War.

By indorsement of the 16th February last, the Acting Secretary of War approved the recommendation of this office of February 13, that the amount available for this work be held to await further appropriation by Congress.

By authority of the Secretary of War a Board of Engineer officers was constituted by Special Orders No. 23, Headquarters Corps of Engineers, April 15, 1891, to formulate and submit a project for improving the mouth of Siuslaw River, under the appropriation of September 19, 1890, and the report of this Board, recently received, contains the following language in reference to beginning work at this locality:

"It would seem to be imperatively necessary, in order that it may be efficiently and economically done, that it be not commenced until an amount sufficient to build the north jetty to its full length up to at least low water be made available. This involves about three-fourths of the total cost of that jetty, or $300,000. Should it be found inexpedient to make so large an amount as this available for this work in one sum, or to await its accumulation by small appropriations, a change in the plan of operations might be adopted by which these smaller amounts could be expended with advantage perhaps to the channel over the bar.

"The change suggested would be to provide the necessary plant and appliances, and then commence the construction of a dike on the sand spit near the mouth of the river, at the northern end of the sandy peninsula, and extend this to the north, thus forming a west bank for the river which will keep the ebb water from spilling until it passes around the north end. The result of this will be to hold the channel to the northward and prevent the breaking through and formation of a south channel. No permanent relief, however, can be expected until the two jetties that are to direct the water across the bar are constructed."

It is recommended that the change of plan suggested by the Board, providing for the procurement of the necessary plant and appliances and the commencement of the construction of a dike on the sand spit near the mouth of the river, at the northern end of the sandy peninsula, be authorized, and that the available funds be applied in this direction.

H. M. ADAMS,
Major, Corps of Engineers, in charge.

This was approved the same day by the Secretary of War, and designates the project under which work is to be carried on.

Immediately upon receipt of the requisite authority, preparations to prosecute the work began.

On account of his experience at Yaquina Bay, Mr. G. A. Lyell, assistant engineer, was designated to take charge of the work at the Siuslaw.

On September 5, 1891, Mr. Lyell arrived at the Siuslaw and commenced operations.

The land necessary for a wharf, storehouses, workshops, etc., and the tramway approach to the north jetty was leased from Mr. W. A. Cox for a term of years sufficient to complete the work of improvement for $100 per year.

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The end of the sandy peninsula from which the south jetty must start, and upon which must be located the wharf, storage platforms, etc., for the south jetty, was purchased from Mr. S. J. Beswick for $5 per acre.

It was necessary to build a floating pile driver in order to construct the wharf at the mouth of the river. A locomotive was purchased from H. K. Porter & Co., of Pittsburg, Pa.

Cars of the Yaquina Bay type were procured from New Jersey, and two hoisting engines, steel rails, and the multifarious tools and materials needed in the prosecution of the work were procured.

Two rock scows have been built, and the work is fairly under way.

The wharf under Cannery Hill has been completed.

During September, 1891, a new survey of the entrance to the Siuslaw was made by Mr. John R. Savage, assistant engineer. This was forwarded to the Department with the following letter advocating a change in the project as approved by the Secretary of War:

PORTLAND, OREGON, *December 28, 1891.*

GENERAL: I have the honor to send herewith a blue print of the survey of the Sinslaw River entrance made in September, 1891.

Upon this I have marked, in full red lines, the project for the improvement of the entrance recommended by the Board of Engineers, consisting of Maj. Handbury, Lieut. Burr, and myself.

The position of the main-entrance channel varies naturally in location from the end of the south spit (so marked) to its present position 1 mile to the northward.

In its report, after recommending the project above named, the Board used the following language:

"It would seem to be imperatively necessary, in order that it may be efficiently and economically done, that it be not commenced until an amount sufficient to build the north jetty to its full length up to at least low water be made available. This involves about three-fourths of the total cost of that jetty, or $300,000. Should it be found inexpedient to make so large an amount as this available for the work in one sum, or to await its accumulation by small appropriations, a change in the plan of operations might be adopted by which these smaller amounts could be expended with advantage perhaps to the channel over the bar.

"The change suggested would be to provide the neccessary plant and appliances, and then commence the construction of a dike on the sand spit near the mouth of the river, at the northern end of the sandy peninsula, and extend this to the north, thus forming a west bank for the river which will keep the ebb water from spilling over until it passes around to the north end. The result of this will be to hold the channel to the northward and prevent the breaking through and formation of a south channel. No permanent relief, however, can be expected until the two jetties that are to direct the water across the bar are constructed."

This language was the result of a compromise on the part of the members of the Board. The work, as approved, is shown by the dotted line on the blue print.

The recent survey, made in September last, the results of which are incorporated on the blue print sent herewith, indicates very strongly that the work outlined and approved will be of scarcely any advantage, and give no permanent relief, and that it will form no part of the best plan for the improvement of the river entrance.

The work is so contrary to my sense of what is proper to be done that I feel it to be my duty to protest against it.

The building of the jetty on the dotted line will simply be extending the sand spit to the north and changing the locus of the channel variations to the north. It will do practically no good to the outer channel and bar. If it did, the benefit must of necessity be temporary. I can not but regard it as a waste of money.

Upon the chart can be noticed the southerly trend of the outer channel after it gets by the harbor throat, if it can be so called. This direction compels boats, desirous of entering or leaving, to run in the trough of the sea in a narrow channel only 5 feet in depth at low water, and makes the entrance a fearfully risky one. Any extension of the jetty on the dotted line would not materially better this direction.

If any benefit to the entrance to this river is to result from improvement works, this benefit will arise from doing away with the trough channel and making the entrance channel run directly out to sea, rather than from any increased depth which must remain slight and uncertain.

It is also more than likely that before work could be fairly started, the main channel will have shifted to the southern position, now indicated as a secondary channel.

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In this event the proposed project of building the jetty on the dotted line could not be carried out, except to the extent of following up this channel as it slowly works to the northward. It occupies six to eight years in moving from its southern to its northern position.

A comparison of the September, 1891, survey with the survey of July, 1889, indicates the changes which are constantly going on, bringing nearer and nearer the time when the main channel will occupy its southern position. A single storm, which would pile the outer sands into the channel at the location of the bar, might, and in all probability will, before next summer, cause the southern channel to develop and the northern to be completely closed.

Taking all things into consideration, I believe that it would be far better to expend the money that is available in commencing the north jetty. Any work done on this will not be wasted, while it would be by following the present project.

My project would be to build the necessary wharves and buildings, scows, etc., and to commence the tramway at Cannery Hill, and build it northward to where it turns to cross the river. Then to await with it here until money was available to extend it out toward the sea a sufficient distance and with sufficient strength to fix the northern limit of the channel in its permanent improved location.

I would further state that I laid this matter before Col. G. H. Mendell, division engineer, who replied to me as follows:

"In reply to your letter of the 14th instant, relating to the difficulties which you find to exist in carrying out the approved project for the entrance to the Siuslaw River, I have to say that, under the circumstances of the case, the project having been adopted without any action thereon by this office, it seems appropriate for you to correspond directly with the Department. In case the Department refers your letter to me, it would then be my duty to consider the matter."

The work done so far consists in building floating plant and in constructing a wharf on the main shore, at the foot of Cannery Hill.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

This letter was referred to Col. Mendell, and the following indorsements were made upon it:

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
January 6, 1892.

Respectfully referred to Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division, for report and recommendation.

By command of Brig. Gen. Casey:

H. M. ADAMS,
Major, Corps of Engineers.

[Second indorsement.]

U. S. ENGINEER OFFICE.
San Francisco, Cal., January 25, 1892.

Respectfully returned to the Chief of Engineers, U. S. Army.

The alternative work proposed by the Board in the case that sufficient money be not available to construct the north jetty, and shown on the map by a dotted red line, seems to be incompatible with the Board's project. This alternative construction, by closing the south channel forces the entrance to the north into a position not recommended by the Board. It is not seen how the approved project can be carried out if the dotted red line alignment be constructed.

The approved project involves a difficulty, in that the north jetty cuts off the actual channel before a new one is provided, thus interrupting navigation. This difficulty will be met by not at first carrying the north tramway over the channel, but, instead of doing this, by laying mattresses over the channel part of the alignment of the north jetty, not, however, completely obstructing the channel, but leaving sufficient depth for navigation over the mattresses. This work will tend to open the proposed new jetty channel. It will, of course, tend to impair the bar channel as it exists at present; but, carried out with judgment, it need not do much harm. The tramway from the wharf on the east side can, in carrying out the project, be extended to the point where it is finally to cross the channel.

It appears to me that as the channel exists, work, if now begun, should be com-

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menced by building the west or south jetty. It will serve as a directrix to the currents and it alone must have some influence in determining the new proposed channel. This influence will be aided by the partial obstruction of the north channel already proposed.

If, during the period of construction, the new channel shall be developed, then it would seem to be good policy to suspend work on the west or south jetty and begin on the north jetty, with a view to holding the new channel in place. It will at this time be expedient to entirely close the channel supposed to have been already partially obstructed.

The lines of the adopted project suggest remark:

The distance between these lines is as much as 1,600 feet. The river maintains a normal depth of about 12 feet where the width is 900 to 1,000 feet.

It is not understood how an adequate channel can be developed and maintained between jetties spaced farther apart than about 900 feet. It is suggested that the alignment of the jetties be reconsidered.

If this be done, it is thought that a modification will be advantageous in the way of softening the right angled change of direction which is observed at the head of the jetties.

The inclosed tracing shows an alternative alignment which eases the curvature by making the bend longer, and by shifting the entrance several hundred feet to the northward.

This alignment is proposed in the way of illustration. It may be varied to suit any local conditions or requirements not mentioned in the report of the Board.

The channel may be trained, if necessary, to a needful distance from the concave face by a few short groins or by paving with brush mattresses.

Reference may be made to indorsement of January 15, 1891, upon a project submitted by Capt. Symons.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

[Third indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
February 1, 1892.

Respectfully returned to Capt. Symons for remark, attention being called to the second indorsement.

To be returned through division engineer.

By command of Brig. Gen. Casey:

H. M. ADAMS,
Major, Corps of Engineers.

[Fourth indorsement.]

U. S. ENGINEER OFFICE,
Portland, Oregon, February 8, 1892.

Respectfully returned to the Chief of Engineers, U. S. Army, through Col. G. H. Mendell, Division Engineer.

I am in substantial accord with Col. Mendell as shown in the preceding indorsement.

In the Board's project the crossing of the channel by the north jetty was determined in location principally on account of the soft sandstone which there juts out from the main shore and upon which a stone jetty could be founded with more surety than upon the sands elsewhere.

As this turn is a critical point with the jetty, it was deemed best to take advantage of this hard bottom.

In order to utilize and take advantage of this hard bottom, it is suggested that the adopted north jetty start from the main shore at the Board's location and end at Col. Mendell's location. This would tend to somewhat ease the curve.

This, with the south jetty location suggested by Col. Mendell, would be entirely acceptable to me.

I inclose a second blue print upon which I have laid down the lines as above outlined. I believe it will be advisable to leave an increased width between the jetties at the turn. Further contraction here seems unnecessary as natural causes will cause a deep channel to exist along the concave side of the north jetty, and if this channel be narrowed, there might be an undue tendency to undermine the jetty.

As regards the sequence of the work, I would recommend that the tramway to the north jetty along the main shore be first built and the jetty extended out into the river, but stopped at such a point as to leave in the present channel ample room for

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the passage of boats. Then, in the open part of the channel, to put down the mattresses suggested by Col. Mendell.

The north jetty so built would be very valuable in handling these mattresses. This being done, work to be stopped, and the south jetty commenced.

With the north jetty in the state outlined we would be prepared to take advantage of the breaking through of the south channel at any time, to push the jetty, and hold the channel in its southern position.

In this I believe I am substantially in accord with Col. Mendell's views.

THOS. W. SYMONS,
Captain, Corps of Engineers.

[Fifth indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., February 12, 1892.

Respectfully returned to the Chief of Engineers, U. S. Army.

The existence of the ledge of sandstone not, however, mentioned in the Board's report, is a good reason for the location of the north jetty proposed by the Board, and this location is for this reason recommended.

The order of work proposed, fourth indorsement, is recommended.

I am not at present prepared to recommend the location shown on blue print for the south jetty, the interval between the two jetties at some points appearing yet rather great. The work recommended for north jetty will, it is supposed, be as much as can be done with the present appropriation, and, if the Department shall approve, it is suggested that the final location of the south jetty be deferred for consideration at a future time.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

[Sixth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
February 19, 1892.

Respectfully returned approved as recommended by division engineer in fifth indorsement.

When such record as may be necessary has been made, this paper will be returned to this office.

By command of Brig. Gen. Casey:

H. M. ADAMS,
Major, Corps of Engineers.

[Seventh indorsement.]

U. S. ENGINEER'S OFFICE,
San Francisco, Cal., February 27, 1892.

Respectfully transmitted to Capt. Thomas W. Symons, Corps of Engineers, U. S. A., Portland, Oregon, attention invited to preceding indorsement of Chief of Engineers.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer.

These indorsements convey an order changing the project for the work to the main project of the Board of Engineers, and upon this project work is in progress.

Early in 1892, the south channel opened, and since has been the principal channel used by boats entering and leaving the river.

Recommendations and remarks.—The south channel having broken through and become the best channel, all questions, for the present at least, concerning the stoppage of the north channel to navigation by the building of the north jetty across the river can be left out of consideration.

If the north jetty is once completed across the river, forming thus an artificial headland to turn the waters into the south channel, it is be-

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lieved that this main entrance channel will be maintained generally in its southern position, although until the completion of the jetties it will undoubtedly wander about more or less.

Two general methods of procedure in the construction of the north jetty are applicable, depending upon the amount of money available: First, if there should be a sufficient amount of money available, this jetty should be built out for its full length as rapidly as possible, the enrockment being brought up to at least low-water level, and to subsequently have rock added until it reaches full high-water level.

To carry out the project by this method a sum of $250,000 can be profitably expended during the next fiscal year.

The second method of procedure is to push the jetty toward the sea, completing it as it progresses by bringing the enrockment up to full high-tide level.

To carry out the project by this method a sum of $50,000 can be profitably expended during the next fiscal year.

As it is probable this will have to be the method adopted, $50,000 is the amount specified in the money statement that can be profitably expended.

Future operations.—Future operations will consist in the extension of the north jetty to as great an extent as possible with the money available.

The report of Assistant Engineer G. A. Lyell, which accompanies this report, gives in more full detail the operations and history of the work.

Money statement.

July 1, 1891, balance unexpended	$49,398.04
June 30, 1892, amount expended during fiscal year	29,816.90
July 1, 1892, balance unexpended	19,581.14
July 1, 1892, outstanding liabilities	2,300.00
July 1, 1892, balance available	17,281.14
Amount appropriated by act approved July 13, 1892	20,000.00
Amount available for fiscal year ending June 30, 1893	37,281.14
Amount (estimated) required for completion of existing project	630,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	50,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. G. A. LYELL, ASSISTANT ENGINEER.

UNITED STATES ASSISTANT ENGINEER'S OFFICE,
Florence, Lane County, Oregon, June 14, 1892.

CAPTAIN: I have the honor to submit the following report of operations on the improvement of the entrance to Siuslaw River, Oregon, for the year ending June 30, 1892.

Under the act of Congress passed September 19, 1890, $50,000 was appropriated for commencing work, and a Board of Engineer Officers appointed April 15, 1891, by Special Orders No. 23, Headquarters Corps of Engineers, to formulate and submit a project for the improvement.

In compliance with instructions contained in your letter of August 5, 1891, directing me to proceed to the Siuslaw to start the work, I turned over the works at Yaquina Bay to Mr. Ricksecker, and then proceeded to Portland to gather data in connection with the project for improving Siuslaw River, and make estimates of materials requisite for construction of plant for carrying on the work.

On September 5, 1891, following your letter of instructions, I arrived at Florence and at once proceeded to find quarters suitable for an office, and succeeded in ob-

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taining the use of a portion of a building belonging to Mr. O. W. Hurd, at a nominal rental.

Soon after my arrival I interviewed Mr. W. A. Cox, the owner of the land at the mouth of the river, in regard to the purchase by the Government of several acres of land for the use of the jetties, but his price was considered too high. On the 19th of October a lease was closed with Mr. Cox for about 3 acres of land, at $100 per annum, during the time of construction of the works of improvement. This land lies along the western slope of Cannery Hill and extends to low-water line.

The beach in front of the leased land, and all along the river bank to the north, is covered with drift logs, wedged in together, some of them of enormous size, with roots attached, lying on the surface and buried in the sand by the winds that shift along the beach. Some of these logs drift into the river from the ocean, but the most of them come down the river and are floated by high tide up and down the river. Some of them float as far up as Acme, about 7 miles, and back again, so that a structure of any kind built near the mouth of the river must be very substantial to resist the constant hammering and pounding of these large logs.

The best location for the tramway leading out to the proposed north jetty will be along the beach, between the high and low water line, as to follow along at the base of the bluff will prove very expensive on account of the large number of drift logs that lie buried under the sand, and will have to be removed in order to drive the piles that support the tramway. The beach, for the most part, is composed of a sandstone of a soft nature, but apparently not subject to scour, upon which large masses of rock can be placed without making an expensive mattress foundation to support the rock.

When once the tramway is constructed to the root of the north jetty and well riprapped, sand will soon fill in behind the tramway and prevent the logs going adrift again.

At the time of my arrival quite a channel had developed at the south, with a strong current, and this channel was quite wide on the inside; the middle-ground sands were found to have encroached to a very great extent on the river between Cannery Hill and signal station "Gulch." Quite an elevation had been formed on the middle-ground since the survey of 1889, and quite an area of drift logs had accumulated. The deepest water, about 7 feet, was found in the south channel on the north side, close to the middle sands; this at low water. The trend of the south channel was decidedly to the southward, just as the north channel has always taken the same direction; and my observations lead me to the belief that the littoral drift is to the south along this part of the coast.

The prevailing winds are from the northwest, as evidenced by the fact that the sand dunes are higher to the south than north of the entrance, and have a steeper inclination on their south than on their north sides. The trees also lean more to the southeast and have fewer limbs on their north than on their south sides.

If the works of improvement are ever completed I believe the inner north channel will fill in entirely with sand from the northwest and will work out for some distance along the north jetty to its top, just as the sands have done at Yaquina along the north side of the north jetty.

On the 3d of last December a furious gale set in from the westward, the wind attained a high velocity and lasted for several hours; trees were uprooted; great clouds of sand blew all the way across the river from the sand dunes on the opposite side, and a very high tide occurred, being about 4 feet above the average, which floated immense drift logs. Considerable shoaling occurred all along the west bank of the river to its mouth and choked up very perceptibly the inner south channel, and shoaled the bar at the north channel. At one time the sand dunes on the west were so low that a vessel could be seen at sea, standing on the lower wharf at Florence.

No damage was sustained by the storm.

The past spring was very stormy and much rain fell.

During the calm intervals the south channel was much benefited by the long run out of the high tides, some of which in April had a difference in elevation of 8 to 10 feet, running, say, from extreme high water at 9 feet to 1 foot below zero.

During the month of March the north channel appeared at times to be almost closed, while the south channel was constantly improving. On the 22d of March the steamer *Chance* arrived, having crossed the bar at the north channel. Stormy weather prevailed which detained her at Florence, and on the 6th of April she crossed out to sea in the south channel, which was wide, and 12 feet at high water was found, this being the first time in a number of years that the south channel has been navigable.

The crossing of the *Chance* through the south channel was followed by four other crossings, in April, in and out at the same place.

On the 15th of May the north channel had shoaled to such an extent that there was no perceptible current except on the last of the ebb tide, and the outlet had worked south to a position a little southwest of station "Gulch," and a person could walk on the sand spit outside the north channel to a point due west of station

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"Gulch." So much has the south channel worked to the south that on the 8th of June a small spit had formed just inside the south channel, having been washed off the end of the south spit.

The surf has laid bare all the rocky beach in the river opposite the south channel. An eddy has been formed just north of the wharf which holds the sand in suspension, and much sand has been deposited at the north side of the wharf, making quite a shoal place. This is helped to a great extent by the projecting nature of the river bank in the vicinity of Cannery Hill, which deflects the current toward the south spit, but as the river widens just below, the force of the deflected current is lost by spreading so much, and the river shoals from 20 feet opposite Cannery Hill to 9 feet near the opposite shore and at the wider part of the river.

The map of the 1889 survey, and that of the 1891 survey, show very nearly the same configuration of the bed of the river just below Cannery Hill, *i. e.*, deep water on the east side, and shoaling up in a northwesterly direction toward the west bank. It seems to me these conditions ought to govern the distance of the jetties apart midway of their curves, and they should not be over 1,000 feet apart, converging to 600 feet at their outer ends. These distances of the jetties apart would not create a greater velocity in the ebb and flood currents than now exists at the narrow portion of the river above Cannery Hill, where the banks of the river are comparatively straight.

It might be urged that the distance of 1,000 feet between the jetties on the inside would tend to throw the current against the north jetty, and undermine it; but, as heretofore stated, the point at Cannery Hill deflects the current toward the west bank, which breaks its force below this point. The strongest currents are developed in the last two hours of the ebb; the flood-tide currents are not so strong.

The river bed in the vicinity of the proposed jetties is, for the most part, sandstone of a soft nature, not however liable to be cut out by the currents. The map of the 1889 survey shows the north channel at its best when fully developed, as it was when the survey was made.

The north or right bank follows the direction of a curve with a radius approximating 3,000 feet, and very regular. I observed, at the time the 1889 survey was made, strong currents on the ebb, but the right bank was so uniform (fine sand) that it was scarcely disturbed to any great extent before the tide would change to flood, and counteract any tendency to much scouring. A study of these conditions must be the guide to a very great extent for the final location, degree of curvature, etc., for the jetties.

Survey.—On the 9th of September the steamer *Gen. H. G. Wright* arrived at Florence, with Mr. J. R. Savage in charge, to make a survey of the bar at the entrance to the river; having completed the survey, the steamer departed on the 20th for Coos Bay.

Operations.—Owing to infrequent trips made by the steamer *George H. Chance* to Florence, much time was lost in getting the work started, and this has caused many interruptions in carrying on the work since its commencement.

A tool house about 14 by 16 feet was built of rough boards near the cannery at Florence. This house has been used for storage purposes, and served well as a place in which to spin oakum for calking, and also for light jobbing work.

A small landing place for receiving lumber for construction of pile-driver scow was also built in front of the tool house.

Launch ways were laid on the flat just west of the cannery, upon which the pile-driver scow was built.

Floating pile-driver.—On the 7th of October work was commenced on a derrick for the floating driver, and on the 9th the steamer *Chance* arrived, bringing materials for the work.

The scow is built of sound fir lumber; length, 52 feet 8 inches; width, 22 feet 8 inches; depth of hold, 4 feet. Deck and bottom planking, 3 inches thick; gunwales, 6 inches thick; two longitudinal bulkheads, 6 inches thick, with three intermediate longitudinal trusses and three equidistant cross trusses all strongly braced, spiked, and bolted.

There are three wooden box pumps; three stout cavils each side, and three hatches.

A derrick with leaders 47 feet long is provided. This derrick has double sheaves on the head block, one for hammer rope and the other for pile-hoist. Five platforms are provided upon which to handle the piles while being driven. A movable block is provided at one end on the fourth platform upon which the hammer rests when not in use, and this block can be worked in and out of position by a small rope running down the back brace nearly to the deck of the scow and obviates the necessity of sending a man aloft to chock the hammer. The leaders of the derrick are lined on their inner edges with ¼ by 2½ inch strap iron to prevent abrasion by the hammer. The hammer is of cast iron and weighs 3,600 pounds, and has a total fall in the leaders of about 30 feet.

The scow and derrick were completeley finished and launched on the 28th of No-

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vember and tied up to await the arrival of the hoisting engine. Bad weather somewhat delayed construction of the scow, as there was no shed over it to protect the men while at work.

Skiff.—On the 27th of November a large skiff was completed. This skiff was designed for use in connection with the floating pile-driver in handling anchors, piles, and lumber, and has been used by the pile-driver crew in towing a small scow loaded with lumber; also in towing piles and carrying other materials to the mouth of the river. It is provided with rowlocks for six oars and has a carrying capacity of about 3½ tons. This boat has proved of valuable assistance to the work.

Scow shed.—On the 9th of December the yard where the floating pile-driver was built was cleared of the launch way, landing, etc., and everything except tool house was moved to Spence Point, about 1 mile below Florence, where permission was obtained to utilize ground near Cline & Smith's new sawmill for a boat yard upon which to construct two rock scows, the ground being above high tides and convenient to the sawmill, where arrangements had been made for procuring lumber. The ground was cleared and a shed erected, under which two scows have been built. This shed is 28 by 90 feet, roofed with rough boards strongly strutted and braced, and left open at the ends and sides.

Last winter a heavy gale of wind blew off a portion of one end of the shed, but did no other damage.

A track was laid down about 130 feet from the shed to the sawmill and one of the light push cars was placed upon it for transferring the scow lumber from the mill, and has proved a saving in handling the heavy timbers.

Rock scows.—Two large rock scows have been built. They are all 90 feet long and 28 feet wide on deck; depth of hold, 6 feet. Gunwales are 6 inches thick.

There are three longitudinal bulkheads 6 inches thick, and four longitudinal frame trusses. Bottom and deck planking is 3 inches thick. The bottom planking is fastened with galvanized iron boat spikes and painted with one coat of copper paint. The sides are painted with two coats red metallic paint in linseed oil, and has been found to stand the action of salt water better than the white-lead paint, and is far cheaper.

The decks were given one coat of hot coal tar. These scows are provided with one 300-pound anchor; a gypsy windlass, bitts, and chocks are placed fore and aft. Three large wooden cavils are provided on each side. These scows draw 14 inches empty, and have a capacity of about 240 tons on a 4½-foot draft.

Mess house and bunk house.—On the 18th of December last a small force was put at work clearing the ground of logs and brush preparatory to construction of the houses. Both houses are located at the base of Cannery Hill, and were built upon cedar posts placed 10 feet apart. The floors of each building are about 20 feet above mean low water. The posts were well braced all around, as the wind blows very hard at the mouth of the river during storms.

Bunk house.—The bunk house is 24 by 72 feet inside, covered with rough boards nailed diagonally to studding to brace the building. On the rough boards are fastened ¾-inch rustic siding. The roof is covered with cedar shingles with a ventilator along the ridge.

Bunks are provided to accommodate 36 men. Four small rooms are also provided for use of foremen. A public room is provided at one end.

Mess house.—The mess house is located 114 feet from the bunk house, and was similarly constructed. It has a kitchen and pantry on one side of a covered passageway, and on the other side two dining rooms, one public and the other private. The private dining room has a small bedroom adjoining.

The kitchen has a formed ventilator in the ridge of the roof for carrying off odors.

On the 6th of January the steamer *Chance* brought in the hoisting engine for the floating pile-driver, and on the 8th it was placed aboard the scow and the work of cleaning and setting up the machinery began.

The weather was stormy and little progress could be made with the work.

Piles, etc.—On the 19th of January bids were received for furnishing 100 piles for the receiving wharf at the mouth of the river, and a contract was made at 4¼ cents per linear foot delivered at Florence.

On the 3d of February a raft of 100 piles was received, and on the 5th the steamer *Lillian* towed the driver to the mouth of the river, where 8 piles were driven on the west bank of the river opposite the old cannery, to serve as a berth for mooring the driver when not in use. The machinery worked very well, although new.

Receiving wharf.—The receiving wharf is located with its front 200 feet from the base of Cannery Hill with an approach 20 feet wide. Dimensions of the wharf are, length, 130 feet; width, 40 feet.

There are 5 longitudinal rows of fir piles driven 10 feet apart each way, and capped with 12 by 12 inch pieces drift bolted to piles. Braces and struts were placed in alternate longitudinal and transverse rows of piles, all securely spiked. Stringers

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6 by 12 inches were placed over each transverse row of piles, and between the stringers 3 by 12 inch joists were placed.

The flooring is composed of 2 by 12 inch planks spiked to stringers and joists.

An incline was placed at the south end of the wharf for landing lumber and other materials.

Pile-driving, etc.—Pile-driving for the wharf was attended with some difficulty on account of the heavy swells from the ocean making it difficult to keep the pile-driver in position; the crew, too, were untrained for such work. The river bed being rather hard, driving was very slow work. The average penetration was about 8 feet through a layer of sand, then into decomposed or soft sandstone, and there will be no danger from the scouring effect of the current. The front row of piles for the warf was driven in water 10 to 12 feet deep at low tide.

Hoisting engine for wharf.—The hoisting engine for wharf has been received and placed in position on the wharf, but the boiler is not yet in position. This engine was built at the works of J. S. Mundy & Co., Newark, N. J. Has two cylinders 9 by 16 inches; single drum; 50 horse power, and substantially built.

The derrick machinery for wharf has been received, but has not yet been set up.

Locomotive.—The locomotive "Siuslaw" has been received and stored on the wharf. This locomotive was built at the works of H. K. Porter & Co., Pittsburg, Pa. It is a 9-ton engine with 4 drivers; a saddle tank and trailing tender with 2 wheels. Has patent brakes, and altogether is very substantially built.

Dump cars.—Irons for 12 dump cars have been received. These have been overhauled and given a coat of metallic paint. Not having the wharf ready upon which to set up the cars, the irons were stored under the mess house. The cars will be similar to those in use at Yaquina Bay.

Lumber for all the cars is now being prepared at one of the sawmills and they will be set up as soon as practicable. They will have a capacity of 8 tons each, and with a 9-ton locomotive on each jetty long trains of cars can readily be handled and the work expeditiously done.

Rails and fastenings.—Thirty-four tons of 30-pound steel rails with the necessary switches, frogs, and fastenings, have been received. They have all been given a coat of red metallic paint in boiled linseed oil, to protect them from the weather.

Rock Quarry.—The site selected for the rock quarry is located at Point Terrace post-office, about 12 miles above Florence. The rock crops out in bold pinnacles above the river bank with very little vegetation growing on top of it, and can be easily quarried. This rock is of a very fine grain, hard, and takes a polish, and would be suitable for all kinds of building purposes. Nearly 2½ acres have been inclosed by survey and comprise the best part of the quarry. Water for engine purposes and for mess and bunk houses is easily accessible. The river at quarry site is very deep with steep banks.

Mrs. J. R. Stiles is the owner of the quarry, and has consented to make a lease to the Government for all rock needed on the works of improvement at 2½ cents per ton. This would carry with it also the privilege of erecting buildings, collecting water for the various purposes of the work, and erecting a wharf and tank for the tow-boats, etc.

There are other good ledges of sandstone rock on the river, but none so well located for quarrying as that at Point Terrace.

Cost of plant, etc.

2 scows	$3,491.23
1 locomotive	2,824.99
1 floating pile-driver (complete)	2,921.32
1 small boat	45.00
1 skiff	81.00
12 dump cars (irons for)	2,000.00
4 push cars	250.00
4 trucks for tramway driver	667.00
1 hoisting engine	2,000.00
Do	1,615.00
1 derrick (incomplete)	260.00
Steel rails, frogs, switches, and fastenings	2,250.00
Miscellaneous (small tools, etc.)	431.00
Total	18,836.54
Cost of mess house and bunk house	1,620.00
Cost of wharf approach, etc	1,760.00

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Materials of construction and cost of same.

Dressed clear lumber for pile-driver derricks	per 1,000 feet B. M.	$15.00
Rough lumber for pile-driver scow	per M.	10.50
Rough lumber for mess and bunk houses	do.	8.00
Dressed lumber for mess and bunk houses	do.	16.00
Rough lumber for scows 1 and 2	do.	10.00
Do	do.	11.00
Rough lumber for wharf and approach	do.	7.00
Do	do.	6.88
Do	do.	4.00
Rough lumber for locomotive house	do.	7.50
Rough lumber for car shop	do.	6.88
Do	do.	7.50
Shingles	do.	2.30
Do	do.	2.50
Dressed lumber for scow No. 3	do.	12.25
Rough lumber for scow No. 3	do.	8.50
Piles	per linear foot	.04¼
Do	do.	.05

Piles used for wharf and building, 124.

Lumber used in construction of—	Feet, B. M.
Wharf, etc	73,966
Buildings	42,717
Two rock scows	96,040
Pile-driver, etc	24,215
Sheds, launch ways, etc	23,401
Total	260,339

On the 14th of February last the steamer *George H. Chance* ran aground on the sand spit about one-fourth of a mile inside the bar. The bar was rough at the time and the master of the *Chance* reported 15 feet. He missed the channel entirely after crossing the bar. As the steamer was loaded heavily with steel rails and car irons for the Government, besides a large miscellaneous cargo, it was feared that she would settle into the sands and become a wreck. I therefore set a crew of men at work removing the Government property on her to the highest part of the sand spit, a distance of half a mile from the steamer. This had to be done at night, the time of the lowest tides, as the steamer was high on the sands at low tide. Everything was safely moved, and the merchants to whom goods were consigned had their stuff all removed. Kedge anchors were then put out and the steamer was gradually worked over the spit at the high tides towards the river channel, and on the 25th of February was safely in deep water again. She sailed for Coos Bay in a few days, was repaired and resumed her route, running from Coos Bay to Coquille, Siuslaw, and Yaquina Bay.

Commercial statistics.—Florence is in the collection district of Yaquina, and was settled in 1876.

The commercial importance of Florence now depends solely upon the steamer *Chance*, which makes irregular trips, and the small coasting schooners which have been running to the place.

There is no line of steamers running direct to Florence at this time.

No outlet exists to the valley except over a very rough mountain road almost impassable in winter, and down the beach via the Umpqua River, over both of which routes mails and passengers are carried.

A mail now goes twice a week to Waldport on Alsea Bay, and Newport on Yaquina Bay, via Hecata and Cape Perpetua, formerly on horseback; now, however, it goes as far as Hecata by wagon over the new light-house road.

The industries on the river are, 3 steam sawmills, 1 saw and planing mill, with facilities for the manufacture of house trimmings, 1 salmon cannery in operation, and a chair factory.

Population of Florence is about 300 souls.

There are 2 stores well stocked with merchandise, 1 newspaper and job printing office, 2 hotels, 1 blacksmith shop, and 2 cooper shops.

The religious denominations are divided between the Presbyterians and Methodists. The Presbyterians have a neat church.

There are several places on the river where sandstone crops out, but the best locality for a quarry is that at Point Terrace, about 12 miles above Florence.

Large bodies of fine fir timber exist on the upper tributaries of the river and in the gulches. Maple and alder abound in great quantities and will some day demand more attention than at present for furniture and other purposes. Cedar is used

almost exclusively for shingles, but none are shipped. Some cedar lumber is manufactured and shipped.

Spruce and hemlock abound, but are not manufactured into lumber to any extent.

Coal is said to exist in the hills to the southeast of Florence.

Rock has been found in the mountains back of Hecata Head indicating the presence of gold.

Clay of a fine quality abounds in the vicinity of Florence, but to what extent is not yet known. Samples have been fired and compare favorably with the manufactured article brought from California, and will make drain tiles, chimney flues, etc.

The run of salmon in the river is not as plentiful now as in former years when two or three canneries could be kept running each season, where only one runs at present with a very light catch. The product is shipped to San Francisco.

Shipping.—The following is a list of the steamers and sail vessels running to Florence during a portion of the year, with their tonnage:

	Tonnage.
Steam schooner *George H. Chance*	71.17
Steam schooner *Mischief*	48.43
Schooner *Free Trade*	86
Schooner *Albion*	70
Schooner *Amethyst*	71
Schooner *Helen Merriam*	70
Schooner *Mary De Léo*	50

The schooners were all from San Francisco, and brought merchandise, and returned loaded with lumber.

The small steamer *Lillian*, belonging to Florence, runs as a towboat on the river and tows the schooners to sea, but she is hardly large enough for the service. The trade does not as yet justify the employment of a regular tug.

The bar, with an average depth at present of about 7 feet at low water, does not justify the employment of large craft in the trade. The small schooners now running here bring loaded only 15 or 20 tons of merchandise, and therefore run very light. They can cross in at half tide, and the practice has been to station the steamer *Lillian* close down to the bar and let the vessels sail in to her; then they are taken in tow and brought up the river.

There are three small steamers running on the river; they are the *Lillian*, *Coos*, and *Mink*. The latter was engaged until recently in carrying the mails and passengers between Florence and the head of tide.

The *Coos* has now taken the place of the *Mink* on the route, as she is a side-wheeler and has better accommodations.

The question of building a railroad between Eugene and Florence has been agitated for some time past, but no definite arrangements looking to its early commencement have as yet been effected. Such an expensive undertaking does not, at the present time, seem to offer inducements for the investment of capital. A good well-graded wagon road, built from the head of tide to Eugene, would suffice for the present needs of trade.

Should the bar ever be improved, Florence would become quite a shipping point, and a railroad built from here to Eugene and on to a connection with some eastern line would offer another competing line for carrying the products of the Willamette Valley and the country east of the Cascade Range to market.

On the 14th instant the steamer *Lillian* towed the schooner *Amethyst* to sea loaded with lumber for San Francisco. The bar was smooth and the master of the *Lillian* reports that he found 12 feet at high water with a 6½-foot tide; the inner channel showed 19 feet close to the bar, which is in the form of a ridge, with a steep slope outside running at once from 15 to 20 feet. It is to be regretted that a careful survey can not at the present time be made.

Northwest winds have prevailed of late with fog, but if an opportunity presents I will endeavor to run a few lines with the *Lillian* out over the bar.

Capt. S. R. Babbidge was connected with the work for several months as foreman, but recently resigned to accept a position at Newport. He proved of valuable assistance to me in getting the work started.

In compliance with regulations the men work 8 hours a day, but under emergencies, and to take advantage of the weather, tides, etc., this time is increased.

In conclusion I desire to acknowledge the prompt attention given by all employed on the work.

Very respectfully, your obedient servant,

GWYNN A. LYELL,
Assistant Engineer.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

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The following table has been compiled from the records of this office and is approximately complete for the past year.

Commercial statistics for past years are not attainable, other than those already published in reports relative to this place.

Shipping, 1891–'92.

	No.	Tons.
Arrivals	22	761
Departures	23	1,620
Total	45	2,381
Built	1	30
Steamers and vessels running to Florence	9	496

Arrivals and departures of passengers by steamer, 36.

Articles.	Tons.	Articles.	Tons.
Exports.		*Imports*—continued.	
Salmon:			
Salt (144 barrels)	22	Hay	10
Canned (2,121 cases)	74	Lime	10
Hides, green	2	Cement	36
Miscellaneous	3	Flour and feed	143
Lumber, fir, and cedar (868,000 feet, B. M.)	1,519	Shingles (25,000)	5
		Boiler and fixtures	3
Total	1,620	Powder	2
		Tin plate	34
Imports.		Salt	4
		Pig tin, and lead	3
Miscellaneous, merchandise, etc	346		
Steel rails, locomotive, hoisting engine, dump cars, etc., for jetty construction	165	Total	761

T T 5.

IMPROVEMENT OF ENTRANCE TO YAQUINA BAY, OREGON.

Description of original condition.—The usual prevailing depths over the bar at low water, before improvement, were from 7 feet to 8 feet. Three distinct channels existed, known as the north, middle, and south channels. The south channel was the one mostly used, but was rendered dangerous by the presence of rocks. The middle channel, though free from rocks, was usually the shoalest of the three, and so was little used. The north channel, besides being long and tortuous, was so studded with rocks as to be considered unnavigable. Owing to the shifting nature of the bar these channels were constantly changing, both in position and depth.

The mean rise of tide was 7.1 feet.

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Plan of improvement.—The project adopted in 1881 was to run out a dike or jetty on the south side of the entrance so as to cause the south channel to shoal up and the flow to be deflected northward, with a view to opening and maintaining the central channel with a least depth of 17 feet at high water.

As originally projected the dike was to start from near low-water line and run out into the sea a distance of 2,500 feet, and was to rise to 2 feet above mean low water. The beach on the line of the jetty from high-water level was to be protected by sinking gabions in the beach with sand heaped over them, and by covering the surface with a layer of mattresses and stone.

The stone for the jetty was to be deposited in place from barges, and cribs were to be used if practicable. It was found, however, that cribs could not be used on account of the strong currents and high seas, and that the ocean swell, even in quiet weather, was too great to permit the use of stone barges. Accordingly the jetty had to be built from the shore end by carrying the stone out over a tramway, and was begun at high-tide line instead of at low-tide line, thus making the total projected length of the jetty in 1881, 3,700 feet.

In 1884, the jetty was extended shoreward a distance of 316 feet, to close a gap that had been washed out by the sea, making the total projected length at that time about 4,000 feet.

The present project, adopted in 1888, is to raise the south jetty to full high water without extending it seaward, thus making its total length 3,748 feet, and to construct a mid-tide jetty on the north side of the entrance about 2,300 feet in length, extending from the north head along and behind the reef putting out from the head to a point opposite the end of the south jetty and distant from it about 1,000 feet.

APPROPRIATIONS.

Act of	
June 14, 1880	$40,000
March 3, 1881	10,000
August 2, 1882	60,000
July 5, 1884	50,000
August 5, 1886	75,000
August 11, 1888	150,000
September 19, 1890	165,000
Total	550,000

Amount expended to June 30, 1891, was $451,239.57.

Results obtained to June 30, 1891.—The following extract from my last annual report gives the results which had been obtained to June 30, 1891:

The work during the past fiscal year has been chiefly confined to the extension of the north jetty. The tramway of this jetty has been extended 600 feet, and 30,327 tons of rock have been placed upon this new extension and the old portion of the jetty.

Mr. Lyell, the assistant in charge, reports that there has been a general depth on the bar throughout the year of 10 to 12 feet at low water.

The tendency of the channel to run straight out has been materially increased by the extension of the north jetty. The full results of the work done can not be realized until the north jetty is built out to an equal length with the south jetty.

Under the influence of the southerly winds, sand is moved and accumulates under the lee of the south jetty, and the ebb current not being strong enough to scour it away it is deflected to the north and finds its way to the ocean without doing much good on the bar. This accumulation of sand on the channel side of either jetty will not, in all probability, be possible when the north jetty is completed.

The recent careful survey of the Yaquina entrance shows a low-water depth of 11 feet.

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In the last annual report was published a plat showing the conditions of the entrance from surveys made in June and July, 1891.

The amount expended during the fiscal year ending June 30, 1892, was $84,108.69.

Results obtained to June 30, 1892.—During the year the north jetty has been extended 840 feet. Of this 405 feet is in an incomplete condition.

A large portion of the south jetty has been completed by bringing the enrockment up to full high tide.

The results obtained by the work done during the past year have been highly satisfactory. The extension of the north jetty has prevented the formation of a sand bank under the lee of the south jetty, and the entrance channel has been continuously straight.

The bar depth of 11 feet at low water reported last year has been materially increased. During the past winter it was constantly reported by the pilot in charge of the bar tug that there was from 12 to 15 feet on the bar at low water. Recent soundings taken by the tug indicate even a greater depth than this, and it is believed that the bar channel now has a least depth of 16 to 18 feet.

It is intended to make a careful survey during the summer as soon as the north jetty is extended to its full length to determine the actual conditions on the bar.

Report of operations.—Mr. Eugene Ricksecker assumed local charge of the work at Yaquina Bay on August 18, 1891, relieving Mr. Gwynn A. Lyell, who was placed in charge of the improvement work at the mouth of the Siuslaw River.

The extension of the north jetty tramway was continued from the beginning of the fiscal year until early in October, 1891. A heavy storm on September 8, having torn away two completed bents and one partially completed one, and further damage being threatened, it was recommended September 21 that work on the north jetty be stopped temporarily and not resumed until the weather should be more favorable, and that in the meanwhile operations be transferred to the south side. This was approved under date of October 1, 1891. By October 8 the bents carried away had been replaced and the tramway extended one bent farther, when operations ceased.

The amount of tramway built since March 28, 1891, was 69 bents, or 1,035 feet, making a total length of 4,153 feet, of which 435 feet were constructed after June 30, 1891. The approach to the north jetty is 2,100 feet in length.

The work of dumping rock on the north jetty was continued until February 13, 1892. By this time 41,530 tons had been placed on the jetty since February 1, 1891, and the enrockment was fully equally to that called for by the project. As the rock composing the jetty rests practically on a rock bottom, comparatively little settlement is expected.

During July, 1891, the trestle approach to the new wharf on the south side was extended 1,200 feet. During August all the piles necessary for the wharf and trestle were driven and the work was completed in September. The new wharf is 3,500 feet from the old one; 2,088 feet of this trestle had been built previous to July 1, 1891.

Early in October operations began on the south side, and during that month an engine and tool house were completed and a number of old dump cars were repaired.

During November, and until the middle of December, repairs to the old tramway were in progress, then the work of dumping rock began. By the middle of February, the enrockment had reached a nearly uni-

form elevation of 19 feet to a point where the sand dunes meet the jetty 1⅛ miles from the new wharf. Storms during December were unusually severe and the south tramway suffered considerable damage in consequence. During February the tramway was further repaired for a distance of 500 feet.

During the year, 12,519.51 tons of rock were placed on the jetty.

The lower quarry was abandoned February 17th, another slide having occurred there in January. The upper quarry was worked during the entire year. The removal of debris from the upper quarry proving troublesome, it was finally decided to use cars for carrying it away; 400 feet of track were laid. In February, the north side locomotive and cars were transferred to the quarry, and debris was dumped along the river bank on land purchased by authority for that purpose.

Two new scows were built during the winter at an approximate cost for the two of $3,400. They were launched on November 27 and on January 1.

Much miscellaneous work was done during the year, including the overhauling and repairing of several scows; the repairing of the locomotive, cars, and rock boxes; the building and fitting out of a blacksmith shop, and a large amount of general repairing. The plant has been kept throughout in good condition.

Authority having been granted therefor, a naphtha launch for the use of the assistant in charge at Yaquina Bay was purchased at a cost of $937.50. She arrived at Newport on February 11, and is of great service.

By agreement with Mr. Samuel Case, the lease of a strip of land occupied by the tramway leading out to the north jetty was renewed from September 17, 1891, for a period of three years, at a rent of $100 per year, payable semiannually.

The lease of wharf and buildings at Newport expired December 15, 1891, and was then renewed by agreement with Messrs. Winant, Buckly & Warren for a period of three years, at a rent of $180 per annum, payable quarterly.

The lease from L. E. Davis of land on the south side of Yaquina Bay occupied by the tramway, which expired January 1, was renewed for a period of five years, at a rent of $15 per annum.

Recommendations and remarks.—The extension of the north jetty is fraught with much uncertainty. It is founded upon rock. The tramway piles do not penetrate this rock more than a foot or two, and are secured in place by bracing and as soon as possible by dumping rock about them. If, before they are finally secured by the enrockment, a severe storm occurs, the piles are very apt to be washed away. Such has been the case on several occasions. It is hardly possible to estimate what will be the cost of completing this jetty owing to this circumstance.

Last year the amount estimated for the completion of the existing project was $165,000. The river and harbor bill now in Congress carries $75,000 for this work. This leaves a balance on the estimate of $90,000. This is the amount stated that can be profitably expended during the next fiscal year for the completion of the project. It is possible that this amount is in excess of what will be required for the completion of the work. A close estimate of the cost of completing the work can be made one year from the present time.

Future operations.—It is expected to continue work on the north jetty now until it is finally and fully completed in accordance with the

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plan of the Board of Engineers. When this is completed work on the south jetty will be commenced and carried to completion.

The report of Lieut. G. D. Fitch, Corps of Engineers, in personal charge of the work, is herewith.

Money statement.

July 1, 1891, balance unexpended		$98,760.43
Amount refunded March 17, 1892		.25
		98,760.68
Amount expended by Treasury Department	$195.37	
June 30, 1892, amount expended during fiscal year	83,913.32	
		84,108.69
July 1, 1892, balance unexpended		14,651.99
July 1, 1892, outstanding liabilities		4,100.00
July 1, 1892, balance available		10,551.99
Amount appropriated by act approved July 13, 1892		85,000.00
Amount available for fiscal year ending June 30, 1893		95,551.99
Amount (estimated) required for completion of existing project		80,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		80,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF LIEUTENANT G. D. FITCH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Newport, Oregon, June 16, 1892.

SIR: I have the honor to submit the following report of operations on the improvement of the entrance to Yaquina Bay, Oregon, for the fiscal year ending June 30, 1892.

I assumed local charge of this work on April 18, 1892, relieving Mr. Eugene Ricksecker, who had been in charge since August 18, 1891, the date upon which he succeeded Mr. G. A. Lyell.

At the beginning of the fiscal year work was in active progress as follows:

Removing débris from the upper quarry preparatory to getting out rock.

Quarrying at the lower quarry.

Constructing a new wharf and approach on the south side.

Placing rock on the north jetty and driving piles for tramway extension.

Quarry operations.—The lower quarry was worked continuously until February 17, 1892, upon which date it was abandoned on account of a slide having occurred there in January, covering the greater part of the workable ledge.

The upper or Government quarry, which had been reopened in June, 1891, on account of a former slide in the lower quarry during March, 1891, was worked during the entire year. The rock from this quarry is much harder than that from the lower quarry. There was a large quantity of débris to remove from the upper quarry. At first this was placed on scows and dumped along the bank of the river in the vicinity. This method proving objectionable, it was decided to use cars for the purpose. Four hundred feet of track was accordingly laid in February, 1892. Cars and locomotive were transferred from the north side to the quarry, and the débris then dumped on land purchased for the purpose just above the quarry along the river. By this means the earth could be disposed of rapidly, so that now the face of the quarry, except a small part at one end, is free from débris.

During the year the lower quarry furnished 141 scow loads of rock, and the upper quarry 110, averaging about 250 tons per scow. About 50,000 tons of débris were removed from the upper quarry.

The force employed at the quarry consists of: One foreman, at $100 per month; one engine tender, at 37½ cents per hour (he tends both hoisting and locomotive engine and has no fireman); one blacksmith, at 35 cents per hour; one blaster, at 27½ cents per hour, and 24 quarrymen, at 25 cents per hour each.

South side.—At the beginning of the fiscal year the trestle approach to the new receiving wharf had reached a length of 2,088 feet, and was being actively extended. During July, 1891, 1,200 feet of trestle was built. During August all the piles nec-

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essary for the approach and wharf were driven and the work completed in September. The new wharf is 3,500 feet from the old one.

Early in October operations were begun again on the south side, and during that month an engine and tool house was completed and a number of old dump cars were repaired. During November and until the middle of December repairs were made to the old tramway. Then the work of unloading and dumping rock on the south jetty was started.

By the middle of February the enrockment had reached a nearly uniform elevation of 19 feet from a point where the sand dunes meet the jetty out to the old crib, which is about 1½ miles from the new wharf.

On December 16 the wreck of an old vessel, entering the bay under a heavy sea and high tide, struck the south tramway a few hundred feet inside the old wreck *Yaquina Bay*, and tore away about sixteen bents of tramway and superstructure.

Storms during December were unusually severe, and the south tramway suffered in consequence considerable further damage.

During February the south tramway was repaired over a length of 500 feet.

During the latter part of March all work ceased on the south side, and preparations were made for resuming work on the north jetty tramway.

During the year about 12,500 tons of rock were dumped on the south jetty. The only employé on the south side at present is a watchman, at $60 per month.

North jetty.—At the beginning of the fiscal year the north jetty tramway had reached a total length of 3,720 feet, and the work of tramway extension was in active progress.

A heavy storm on September 8 having torn away two complete bents and one partially completed one, and further damage being threatened, authority was obtained to stop work temporarily on the north jetty tramway until the weather should be more favorable. By October 8 the two bents carried away had been replaced and the tramway extended one bent farther.

Operations, except that of dumping rock, were then transferred to the south side, and the extension of the north jetty tramway ceased for the season, twenty-nine bents, or 435 feet, of tramway having been constructed since June 30, 1891.

Work was resumed on the north jetty tramway on April 4, 1892, and by April 21 ten bents had been built. A severe storm on April 24 and 25 carried away six of these bents; three of them had been replaced when another severe storm on April 28 carried away the last bent replaced, and did more or less damage to the six preceding bents. Work had been resumed too early in the season. Since the second storm the weather has not caused further damage. The work of tramway extension has, however, proceeded at a slow rate necessarily, owing to the fact that the bottom is of rock, and as the piles can obtain no penetration, it is necessary to secure each bent by dumping rock before proceeding to the next.

From April 4 until the present time (June 16), 27 bents, or 405 feet, of tramway, have been constructed; making a total length of 4,560 feet, of which 840 feet were constructed during the fiscal year. The tramway will probably be completed by the latter part of July.

The work of dumping rock on the north jetty was continued from the beginning of the fiscal year until February 13, 1892. By this time about 41,000 tons had been placed on the jetty, and the enrockment of the portion already constructed was fully equal to that called for by the project. Rock dumping therefore ceased until April 4, since which date about 8,800 tons of rock have been dumped on the portion of the jetty since then constructed.

The total amount of rock placed on the north jetty during the year was about 49,800 tons. Little settlement is expected, as the dumping was practically on a rock bottom.

The portion of the jetty built this season has reached a height of about 2 feet above mean lower low water, except that the last 60 feet is somewhat lower. Sand is being deposited in large quantities along the ocean side of the north jetty.

The force employed on the north side consists of 1 clerk, at $90 per month; 1 pile-driver foreman, at $105 per month; 1 foreman, at $80 per month; 1 watchman, at $60 per month; 1 storekeeper, at $60 per month; 1 locomotive engineer, at 35 cents per hour; 1 engine tender (pile-driver), at 32½ cents per hour; 1 blacksmith, at 30 cents per hour; 1 engine-tender (hoisting engine), at 27½ cents per hour; 1 train foreman, at 27½ cents per hour; 1 scow foreman, at 27½ cents per hour; 1 dock foreman, at 27½ cents per hour; 4 riggers on pile-driver, at 27½ cents per hour; 3 laborers, at 25 cents per hour, and 6 laborers, at 22½ cents per hour.

Miscellaneous.—Much miscellaneous work was done during the year, including the overhauling and repairing of several scows; the repairing of the locomotive and cars; the construction of a large number of dirt boxes; the building and fitting out of a blacksmith shop, and a large amount of general repairing.

The only additions made to the plant during the past year were two scows built at Toledo by hired labor, and a naphtha launch purchased for the use of the assist-

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ant in charge in visiting the widely separated places of work. The two scows were built during the winter and launched on November 27, 1891, and January 1, respectively. Their cost was as follows:

Cost of material for two scows	$2,182.89
Cost of labor for two scows	1,965.19
Total cost	4,148.08

The naphtha launch, which is 21 feet in length, runs at 65 pounds pressure, consumes 1 gallon of naphtha per hour, and can carry 10 persons. Cost, $937.50.

The launch arrived at Newport on February 11, 1892, and has been of the greatest service.

The steamer *Walluski* is hired at $500 per month to tow rock, lumber, supplies, etc. For this purpose the sum of $5,266.67 was paid during the year.

By agreement with Mr. Samuel Case, the lease of a strip of land occupied by the tramway leading out to the north jetty was renewed from September 17, 1891, for a period of three years, at a rental of $100 per year, payable semiannually.

The lease of wharf and buildings at Newport expired December 15, 1891, and was then renewed with Messrs. Winant, Buckley & Winant, by agreement, for a period of three years, at a rental of $180 per annum, payable quarterly.

The lease from Mr. L. E. Davis of some land on the south side of Yaquina Bay, which expired January 1, 1892, was renewed for a period of five years, at a rental of $15 per annum.

A table of commercial statistics for the year will be sent you at the end of the month.

Very respectfully, your obedient servant,

GRAHAM D. FITCH,
First Lieut., Corps of Engineers.

Capt. THOMAS W. SYMONS,
Corps of Engineers.

COMMERCIAL STATISTICS.

Yaquina Bay is in the collection district of Yaquina. Yaquina is the port of entry. The nearest light-house is at Cape Foulweather, 4¼ miles north of the entrance. Yaquina Bay forms (with the Oregon Pacific Railroad) a competitive line from Portland and Willamette Valley to San Francisco.

The following returns were collected by Lieut. G. D. Fitch, Corps of Engineers, in local charge of the work at Yaquina Bay, and are for the fiscal year ending June 30, 1892:

Arrivals and departures of vessels.

	No.	Aggregate tonnage.
Arrivals	45	21,944.7
Departures	44	23,011
Total	89	44,955.7

Steamers running to and from Yaquina.

	Reg. tonnage.
Steamship *Willamette Valley*	742.69
Steam schooner *Geo. H. Chance*	71.17
Steam schooner *Mischief*	48.43

Steamers running on the bay.—Propeller *T. M. Richardson* runs from Newport to Yaquina City; bar tug *Resolute*, owned and operated by Oregon Development Company; tug *Walluski*, employed by Government in towing rock scows, etc.

No new routes of travel have been established since date of last annual report.

Number of passengers arrived by sea	480
Number of passengers departed by sea	570

One passenger steamer, the *Volanta*, of 74.23 gross and 44.24 net tonnage, was built during the year at Oneatta.

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Exports and imports.

Article.		Quantity.	Article.		Quantity.
Exports.			*Exports*—Continued.		
Wheat	tons	7,260	Seal furs	do	1.9
Oats	do	9,202.1	Miscellaneous merchandise	do	753.8
Lumber	feet, B.M.	214,500	Oil	do	1.5
	tons	429.1	Bones	do	10
Flour and feed	do	981.5	Trees	do	3
Potatoes	do	1,270			
Wool	do	62	Total	do	20,516.8
Ship knees	do	53.8			
Drugs	pounds	200	*Imports.*		
Horses	number	75			
Hay	tons	180	General merchandise	tons	4,792.1
Bark	do	66.9	Machinery	do	47.7
Hardware	do	1.2	Coal	do	201.7
Tin	do	27.2	Hardware	do	1,437.8
Hides	do	18.3	Malt	do	58.4
Seeds	do	6.9			
Salmon	do	167.5	Total	do	6,537.7
Excelsior	do	20			

Estimated value:

Imports	$515,558
Exports	317,294

T T 6.

IMPROVEMENT OF TILLAMOOK BAY AND BAR, OREGON.

Description of original condition.—The channel over the bar is direct and shifts but little, so that the bar is considered one of the safest on the Oregon coast. A fair depth of water is maintained throughout most of the year, and vessels drawing as much as 13 feet can usually enter without difficulty. The bay at low tide consists of three channels running through sand and mud flats. These channels are of fair depth near the entrance, but gradually shoal up, giving depths of only 1 or 2 feet near the head of the bay. Tillamook, the principal town of the region, is situated on a tidal slough above the head of the bay, and can only be reached by light-draft vessels at high tide.

Plan of improvement.—No general plan and project for the improvement of the bay and bar have yet been approved. A special project for the expenditure of the money appropriated by the act of August 11, 1888, has been approved. This consisted in making a survey of the bar and entrance and the construction of longitudinal and spur dikes and shore protection works to deepen the water over Dry Stocking Bar at the mouth of Hoquarton Slough and to remove snags and overhanging trees from Hoquarton Slough.

APPROPRIATIONS.

Act of—	
August 11, 1888	$5,200
September 19, 1890	500
Total	5,700

Amount expended to June 30, 1891.—The amount expended to June 30, 1891, was $4,922.95.

Results obtained to June 30, 1891.—No work was done during the year

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1890–'91, and the condition of affairs remained practically the same as at the end of the previous fiscal year, June 30, 1890.

During the year ending June 30, 1890, a survey of the bar and entrance to the bay was made. Hoquarton Slough was cleared of snags as far as Tillamook City.

During the high water of November and December, 1889, the longitudinal dike and three spur dikes adjacent thereto were washed away. So no results of any practical importance or permanence had been obtained up to June 30, 1890.

The amount expended during the fiscal year ending June 30, 1892, was $709.90.

Results obtained to June 30, 1892.—No work was done beyond the survey hereinafter mentioned, and no results were obtained during the year.

Report of operations.—During July, 1891, a survey of the entrance to Tillamook Bay was made by Mr. John R. Savage. The results of this survey and report thereon are published in House Ex. Doc. No. 35, Fifty-second Congress.

Recommendations and remarks.—A special project for the improvement of Tillamook Bay having been submitted, no further recommendations and remarks are now deemed necessary.

Money statement.

July 1, 1891, balance unexpended	$777.06
June 30, 1892, amount expended during fiscal year	709.90
July 1, 1892, balance unexpended	67.16
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	15,067.16

COMMERCIAL STATISTICS.

Tillamook Bay is in the collection district of Oregon. Astoria, near the mouth of the Columbia River, is the nearest port of entry. The nearest light-house is at Cape Meares, about 4 miles south of the entrance.

The following returns furnished by Mr. Charles Lamb, of Tillamook, are for the year ending June 30, 1892:

The number of vessels of all descriptions crossing in over the bar during the year was 74. The number crossing out was 73. Their names, draft, and registered tonnage are as follows:

Vessels arrived and cleared.

Name.	Trips.	Registered tonnage.	Draft loaded.	
			Ft.	*In.*
Steam schooner Truckee	20	350	13	6
Steam schooner Scotia	12	200	11	4
Steamer Homer	1	420	14	0
Steam schooner R. P. Elmore	12	80	7	6
Steam schooner Augusta	21	87	7	9
Steam schooner W. H. Harrison	5	70	6	9
Steam schooner Geo. H. Chance	2	71.17	9	0
Steam scow Improvement	1	13	4	0

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Vessels built during the year.

Name.	Tonnage.	Draft.
		Feet.
Steamer Gen. Garfield, rebuilt (runs on Tillamook Bay, towing and freight business)	10	7

Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
Exports.			*Imports.*		
Lumber .....feet B. M..	12,650,000	$164,450	Sawmill machinery† .....tons..	50	$14,000
Do.....tons..	25,300	.....	Electric-light plant..do...	30	5,000
Salmon, canned .....do...	684	90,250	Stave factory .....do...	80	5,000
Butter.....do...	30	12,000	General merchandise, ...tons..	5,600	420,000
Eggs .....do...	6	1,500	Agricultural implements.....tons..	150	7,500
Wool .....do...	25	5,000	Flour .....do...	380	11,400
Hides.....do...	5	750	Feed.....do...	350	7,000
Cooperage stock *...do...	100	1,000	Shingles .....do...	125	500
General merchandise, ...tons..	175	13,125	Brick.....do...	130	520
Total.....	26,325	288,075	Total.....	6,895	470,920

* Stave mill just started. † Now under construction.

T T 7.

IMPROVEMENT OF ENTRANCE TO HARBOR AT NEHALEM BAY, OREGON.

Description of original condition.—Nehalem Bay at high water is about 2 miles long by 1⅓ miles wide at widest part, and is connected with the ocean by a narrow channel extending in a southerly direction about 3 miles. This channel varies in width from 1,000 to 2,000 feet at high tide. A low, sandy peninsula, about 2½ miles long and one-fourth mile wide, lies to the west of this channel and separates it from the ocean.

The southern end of this peninsula forms the northern shore of the entrance. Between this and the main shore, limiting the entrance on the south, is a distance of 1 mile. The entrance channel shifts within these limits of 1 mile, occupying sometimes a southerly position and sometimes a northerly one, and sometimes there are two channels separated by a sand island bare at low water. At the time of the survey of June, 1889, a depth of 6 feet was found on the bar at the northern channel. The ordinary bar depth may be stated to be about 5 to 6 feet at low water.

Plan of improvement.—The plan of improvement recommended by Capt. Young was to build two high-tide stone jetties converging until the distance apart is about 500 feet, and then, if necessary, running out to sea parallel to each other to such distance as will insure a low-water depth on the bar of at least 8 feet; the north jetty to rest on the end of the sandy peninsula and the south jetty upon the mainland, the object being to hold the channel in its southerly position.

The cost of the work, as estimated by Capt. W. Young, Corps of Engineers, was $325,927.50.

Subsequent estimates made in May, 1891, show that the cost was underestimated by Capt. Young, and that the work will cost $712,388.

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APPROPRIATION.

Act of September 19, 1890, "for commencement of jetty construction," $10,000.

Amount expended to June 30, 1891.—There were no expenditures for the year ending June 30, 1891.

Results obtained to June 30, 1891.—No work was done and no results obtained.

The amount expended during fiscal year ending June 30, 1892, was $415.08.

Results obtained to June 30, 1892.—No work other than the survey hereinafter mentioned was done and no results were obtained.

Report of operations.—The sum of $10,000 being inadequate even to procure the necessary plant to commence jetty construction at the mouth of the Nehalem, no final project was made or approved, and all work of actual construction was postponed.

During May, 1891, a reëxamination of the entrance was made, and it was found that the north channel had shoaled up, and only the south one was open.

A careful study of the project was made, and the cost of its carrying out estimated, with a result of forcing a conviction that the original estimate was far too low, in fact, not one-half of what the work would actually cost. This was laid before you in my letter of June 11, 1891.

Under date of June 25, 1891, I was informed that the Secretary of War had directed the withholding of the expenditure of the appropriation until Congress shall have taken further action in the matter.

In July, 1891, a resurvey of the Nehalem entrance was made by Mr. John R. Savage, on the steamer *Gen. H. G. Wright.*

Mr. Savage's report accompanies this report.

NEWPORT, OREGON, *July 28, 1891.*

CAPTAIN: I have the honor to submit the following report of the survey of the entrance to Nehalem River, Oregon:

Arrived off the Nehalem River on the steamer *Gen. H. G. Wright* on the morning of Monday, July 20, 1891, and crossed the bar at once and anchored about a quarter of a mile upstream, I found that none of the signals used in former years remained standing, so we started out at once and ran a meander line about 9,000 feet in length along the beach near high-water line, from which the various signals for sounding were located, either by offsets from the line, or, as in the case of the two signals on the spit, by cuts from the adjacent plugs on the meander line.

About two days were taken up in locating and erecting the necessary signals and about half a day in locating the high and low water lines along the shores as far as shown on the map, in each case the mean tide being taken.

The weather was very favorable for work on the bar while we were in the Nehalem, but on account of the shoalness of the water on the bar it was impossible to work more than two hours per day while sounding in the channel, and then only on the two hours of the flood tide preceding high water.

We worked two days on the bar and ran in all twelve lines in and out over the bar, sufficient to give a good idea of its shape and the depth of water to be found on the same, which at mean high tide is about 11 feet, or, in other words, 4 feet at low water with a narrow bar channel 5 to 6 feet in depth, as shown upon the plot.

While sounding upon the bar there were about 115 observations taken with the sextant and about 475 casts of the lead made.

About a day was spent in developing roughly the river for about a mile inside the entrance.

The channel has changed its position very much since the last survey two years ago, and it is now very much more to the south, and what was then the channel is now entirely filled up with sand above the low-water line. The change in the channel is by no means unusual, as I was told that the channel had shifted from the north channel across the spit to its present position and back again two or three times in the last two or three years. The last change occurred some time during this last spring, either in March or April. When Capt. Schrader, of the steamer *Augusta,* went in he used the north channel across the spit, and when he crossed the

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bar again a week later the channel had shifted to the southward, about where it is now.

Two or 3 miles up the river, at a cannery wharf, I found the gauge used by Mr. Lyell in his survey of two years ago, and set up a new gauge with its zero 2 feet below the zero of Mr. Lyell's gauge, which was set to the mean of the lower low waters.

I set the gauge lower so as to catch the extreme low tides that were running while we were in the Nehalem. I also checked the readings taken by comparing them with the times and heights of the tides for the Pacific Coast, which all in the mean were 2 feet less than the readings of the gauge; there was quite a noticeable difference in the times of the low waters, which, however, can easily be accounted for by the gauge being nearly 3 miles from the ocean.

Very respectfully, your obedient servant,

J. R. SAVAGE.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

Under date of February 17, 1892, by indorsement, I was directed to prepare a project and estimate for the improvement of the Nehalem River entrance, including therein a historical account of the variations of the entrance.

My report was made under date of February 29, 1892, and was as follows:

PORTLAND, OREGON, *February 29, 1892.*

GENERAL: I have the honor to acknowledge receipt, by indorsement, of orders to prepare a project and estimate for the improvement of the Nehalem River entrance, including therein a historical account of the variations of the same.

Nehalem Bay, at high water, is about 2 miles long by 1½ mile wide at its widest part, and is connected with the ocean by a narrow channel extending in a southerly direction about 3 miles. This channel varies in width from 1,000 to 2,000 feet at high tide and from 500 to 1,500 at low tide. A low, sandy peninsula, about 2¼ miles long and one-fourth mile wide, lies to the west of this channel and separates it from the ocean. The southern end of this sandy peninsula forms the northern shore of the entrance; between this and the main shore, limiting the entrance on the south, is a distance of 1 mile.

The entrance channel shifts within these limits of 1 mile, sometimes occupying a southerly position and sometimes a northerly position, and sometimes there are two channels separated by a sand island, bare at low water. The channel change from a northern to a southern position is a very common occurrence.

Mr. Savage, who made the last survey in 1891, states that the people told him that this change had taken place two or three times within the same number of years. The last change from a northern to a southern position, previous to the survey of 1891, occurred in March or April of the same year, within the space of a week. He also states that most of the residents on the Nehalem are of the opinion that there is better water over the bar when the channel occupies the northern position.

In the Pacific Coast Pilot, published by the Coast and Geodetic Survey, it is stated, in giving an account of this survey of the river in 1875, that "at the time of the survey in 1875 the low-water channel of the river at the entrance was 160 yards wide, but at the bend, 3 miles inside, it was 650 yards wide. The bar of the river was not sounded, but it was sufficiently near to the observers to be watched from the shore, and for five months they never saw it without a break entirely across it. It was believed to have less than 6 feet of water upon it. The channel evidently shifts with heavy storms. * * *

"In July, 1867, when we were passing close along the coast, we found the Nehalem opening abreast of the position of the north point in 1875. * * *

"In 1868, during an examination of the river, the bar broke continuously and was unapproachable. * * *

"At high water the sea breaks entirely across the narrow channel as far northward as the sand point, effectually closing the river."

The river and harbor act of March 3, 1875, directed that an examination should be made of the mouth of the Nehalem River. This was not done directly by the Corps of Engineers, but was done by Capt. Gilbert, an assistant of the Coast and Geodetic Survey, who was at work in that vicinity, and he made the examination in accordance with orders from the Superintendent of the Coast Survey.

The quotation just given from the Pacific Coast Pilot is based upon Capt. Gilbert's examination.

The mouth of the Nehalem was next examined by Mr. Philip G. Eastwick, under the orders of Capt. Powell. No boat could be obtained for taking soundings on the

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bar, but such observations as Mr. Eastwick was able to make confirmed the estimate of its depth arrived at by Capt. Gilbert. Neither Capt. Gilbert's report nor the report of Mr. Eastwick give any data as to the variations in the entrance channel.

Again, in 1886, another examination was made by Lieut. Edward Burr, of the Corps of Engineers, under the directions of Capt. Powell.

Lieut. Burr states in his report that at the time of his visit to the Nehalem "it was not possible to get out on the bar, as the sea was breaking entirely across the entrance, and there was nothing available, besides, but a rowboat.

"I am under the impression that there is a very small depth of water on the Nehalem Bar. No white man has ever sounded across the bar as far as I could learn. An Indian is said to have done so, and reported 8 feet at low water. But parties interested in small steam coasters, having examined the entrance with the idea of entering there, have declined to do so. Yet an employé of one of these coasters informs me that his vessel enters Nestucca Bay, where the depth on the bar is about 3 feet at low water. Again, on one day that I was at Nehalem Bar, the sea was comparatively smooth, and with a small surf on the beach, yet across Nehalem entrance the sea broke almost as heavily as on the beach.

"The river flows southward parallel to the beach for some 2 miles, and is separated from it by a narrow sand spit. The entrance seems to be working still farther to the south, cutting away the river bank. The channel on the bar is almost a continuation of the river channel above it, and appears to extend through the breakers at a very acute angle to their general line."

As a result of both of these examinations, Capt. Powell reported that the Nehalem entrance was unworthy of improvement.

Lieut. Burr in his report makes no mention of the changes in the entrance channel.

In August, 1888, another examination was made of the Nehalem Bay and Bar by Mr. J. S. Polhemus, under the direction of Capt. Young, and in 1889 a survey was made of the entrance by Mr. Gwynn A. Lyell, also under the direction of Capt. Young.

Mr. Polhemus states in his report that he made no soundings on the bar as it was too rough for the small boat at his disposal. He also states "in my judgment, the Nehalem is worthy of improvement if a careful survey should show this to be possible for a reasonable sum, for the reason that it would afford an outlet for one of the largest and most valuable forests of timber in the State of Oregon, and enable a section of country to support a greatly increased population."

Mr. Polhemus further states that "the channel shifts like on the other coast bars."

Mr. Lyell, in his survey, made in 1889, finds two channels.

Mr. Lyell states in his report: "A second channel exists about three-fourths of a mile south of the present navigable channel. The Coast Survey charts of 1868 and 1875 show this channel open, and that at the north entirely closed at low water. I am not informed as to the period in which the shifting of the channel occurs."

By comparing the surveys of 1889 and 1891 with the survey of 1875 it is seen that the high-water line on the sand spit has moved south about 300 feet, while the same line on the east shore near the southern outlet has moved seaward about the same distance.

Mr. W. H. Wood, assistant engineer, who visited the Nehalem in 1891, was told that the change in the channels usually occurred every year, and about the times when the winds began to change from north to south and south to north.

From all the data available, it is concluded that there is no regular cycle of change in these channels, but that any heavy storm is liable to shift the entrance channel to any point from its northern to its southern position.

Any plan or project of improvement, the carrying out of which must of necessity extend over several years, must therefore ignore these changes to a very great extent.

It seems to me that it is only possible and proper to adopt the general project, and to leave the ultimate definite location of the works to be determined at the time the project is put into execution. I can see no serious defect in the general plan proposed for the improvement of this entrance by Capt. Young, and believe that, with some slight modifications, it should be adopted, leaving, as before stated, the ultimate location of the jetties to be determined when the plan is put into execution.

The essential features of this plan are a south jetty, forming an artificial headland, which shall keep the channel from cutting away to the south, and a north jetty, which shall hold the sands back and prevent them from piling into the channel under the influence of the summer littoral currents from the north, the two together to concentrate the flowing waters upon the bar.

The width between the jetties should be, in my opinion, 600 feet instead of 500, as proposed by Capt. Young, as wherever the river is 600 feet wide there is ample depth, and it is bad policy to choke the entrance against the inflowing waters any more than is necessary.

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The south jetty should not break away from the shore so abruptly, as shown on Capt. Young's plan, but should leave it with a gentle curve.

I send herewith a blue print, upon which I have indicated two possible locations for a pair of jetties.

The extension of the jetties seaward is rather problematical. I have indicated on the plan the extent to which they should go to secure the maximum benefit under existing conditions. The building of the jetties would, however, change existing conditions, and because of the vast volume of sands in the vicinity, and the fact that the Nehalem entrance is in a shallow bight of the coast, it is altogether probable that they will have to be extended farther on account of the accumulation of sands in front of them.

It is probable that by confining the inflowing and outflowing waters between jetties 600 feet apart a bar depth of 8 feet at low water may ordinarily be expected. But this would by no means be permanent. Exposed to the full force of the ocean waves, the movable sands at a depth of 8 feet or less would be stirred up at every moderate storm, and the bar channel reduced temporarily to the ordinary depth before any improvements were undertaken.

It is also safe to predict that there would be times when the bar would exceed 8 feet temporarily.

With such an entrance as the Nehalem it is in my opinion unsafe to predict any permanent bar depth.

Estimates.—Any estimate of the cost of the jetties based upon existing conditions and depths must be approximate and subject to change. These conditions and depths are subject to change naturally, and the construction of the jetties would cause still more marked changes.

In making the following estimates I have assumed the present bottoms, as shown by the last survey, as the basis. The jetties are planned to be rubble mounds, on brush mattresses, built to full high-tide level, 10 feet wide on top, with a slope of 1 on 3 on the channel side from high to low water, and a slope of 1 on 1½ on the side away from the channel between high and low water, and slopes of 1 on 1 on both sides below the water.

In order to provide for settlement of the rubble mound into the sand, and due to scouring in the deeper contracted channel, and to abrasion; an allowance of 6 feet increased depth is made in all estimates except the estimate for the jetty from the end of the North Spit extending southerly and limiting the river on the west. For this portion, from A to B, an allowance of 4 feet is made.

North location.

Estimate:	Feet.	
South Jetty, approximate length	4,500	
Rubble required, 108,308 cubic yards, at $4		$433,232
North Jetty, approximate length	4,200	
Rubble required, 93,367 cubic yards, at $4		373,468
Total		806,700

South location.

Estimate:	Feet.	
South Jetty, approximate length	2,700	
South Jetty, approximate length of tramway approach	5,500	
Rubble required, 69,760 cubic yards, at $4		$279,040
North Jetty, approximate length	6,800	
Rubble required, 115,205 cubic yards, at $4		460,820
Tramway approach, 5,500 feet, at $4		22,000
Total		761,860

The estimated cost of completing the project wherever the jetties are located will be about $800,000.

The cost of the plant necessary and the expenses attendant upon the commencement of this work in a manner commensurate with its magnitude is $50,000.

On account of the lack of any fixed, rocky headland, and the unstable character of the sands upon and in which this work must be founded, and the great changes which are liable to occur at any time, it is particularly necessary and desirable that, once commenced, it be prosecuted with vigor and with ample funds.

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The only justification for this improvement being undertaken is, as stated by Capt. Young, to benefit the lumber business by furnishing a harbor from which the immense amounts of lumber tributary to the Nehalem could be shipped to market.

If a harbor can not be obtained at the Nehalem sufficient in capacity to permit the lumber business to be carried on profitably, the improvement seems unjustifiable, as the other interests involved are comparatively insignificant.

Now to carry on even a coast-wise trade in lumber profitably at present prices, or prices which could confidently be expected for years to come, requires a harbor with a greater depth of water on the bar than can be hoped for at the Nehalem, and a harbor where the vessels are not liable to be bar bound for weeks at a time.

It is not possible for me to believe that such a harbor can be obtained at the Nehalem. The lumber of the Nehalem must be shipped out of the country by some other route.

I entirely coincide with the opinion expressed by Capt. Powell, that the problem of providing this district with means of transportation would be satisfactorily solved by the construction of a railroad to the Columbia River, and by the establishment of a more convenient line of communication to Tillamook Bay.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

Recommendations and remarks.—No project for the improvement of the Nehalem having been definitely and formally decided upon, and no work of construction having been authorized or commenced, I refrain from making any recommendations as to future appropriations, or as to the amount that could be profitably expended upon the work during the next fiscal year.

Money statement.

July 1, 1891, balance unexpended	$10,000.00
June 30, 1892, amount expended during fiscal year	415.08
July 1, 1892, balance unexpended	9,584.92

COMMERCIAL STATISTICS.

The following returns, furnished by Mr. E. G. Wist, of Nehalem, are for the year ending June 30, 1892.

The number of vessels of all descriptions crossing in over the bar during the year was 16. The number crossing out was 16. Their names, registered tonnage, and draft are as follows:

Vessels arrived and cleared.

Name.	Trips.	Registered tonnage.	Draft loaded.
			Ft. In.
Steam schooner Augusta	9	87	7 9
Steam schooner W. H. Harrison	7	70	6 9

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As there were no winter freshets last season and the bar channel having shifted, vessel masters were very cautious and refused to come in; only 1 vessel came in during the month of May.

Articles.	Quantity.	Value.	Articles.	Quantity.	Value.
EXPORTS.			IMPORTS.§		
Box lumber*.....tons..	255	$14,000	Two sawmill outfits.tons..	150	$25,000
Coal†.....do...	5	25	One pile-driving outfit.do..	15	2,000
Butter.....do...	15	6,000	Merchandise and logging machinery.....tons..	650	50,000
Salmon‡.....do...	8	500	Cannery supplies....do...	200	10,000
Salmon, canned.....do...	144	20,000			
Hides and furs.....do...	10	10,000			
Elkhorns and beeswax.do...	3	1,200	Total.....	1,015	87,000
Chittem bark.....do...	3	300			
Total.....	443	52,025			

* Double amount on hand, but unable to ship.
† Sample.
‡ Off year for salmon; double the amount the year previous.
§ The bar channel having shifted, vessel masters were cautious and refused to enter.

T T 8.

IMPROVEMENT OF UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON.

Description of original condition.—Under the above head it has been deemed proper to officially include the continuous Columbia and Snake rivers from Celilo, at the head of The Dalles, to Lewiston.

The Upper Columbia and Snake form a continuous line of navigable river, but broken by many rapids, rendering navigation difficult and dangerous.

These rapids are in nearly every instance caused by rocky bars with occasional bowlders, and the channels were crooked and narrow.

Before improvement the ruling depth at low water was 2 to 3 feet on many of these bars, some of which were practically impassable at low water.

The Columbia was navigable all the year round, except when closed by ice. The Snake was, however, only navigable during high water and for three to four months in the spring of the year.

Plan of improvement.—Previous to 1877 $120,000 had been appropriated for the work of improvement, and had been expended in survey and rock removal at the principal rapids.

In 1877 Maj. J. M. Wilson made a project for the improvement of the upper Columbia and Snake rivers, consisting of removing rock bowlders, and rocky reefs, and scraping gravel bars in the Columbia and Snake as far as Lewiston. The estimated cost of this work was $132,000.

The present project or plan of improvement consists in removal of bowlders, gravel bars, and rock ledges, and putting in such contraction works as may be necessary.

The estimated cost of the work has not been accurately determined because of the lack of continuous and full surveys, because from the nature of things it can not be, as many of the obstructions which it is necessary to remove are continually recurring.

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APPROPRIATIONS.

Upper Columbia River:	
Act June 10, 1873	$50,000
Act June 23, 1874	20,000
Act March 3, 1875	35,000
Total	105,000
Upper Columbia and Snake rivers:	
Act August 14, 1876	15,000
Act June 18, 1878	20,000
Act March 3, 1879	20,000
Act June 14, 1880	15,000
Act March 3, 1881	15,000
Act August 2, 1882	6,000
Act of July 5, 1884	20,000
Act August 5, 1886	10,000
Act August 11, 1888	10,000
Act September 19, 1890	20,000
Total	151,000
Aggregate	256,000

The amount expended on the project to June 30, 1891, was $134,442.23.

Results obtained to June 30, 1891.—Up to this date no work had been done in the river since the report of Maj. Jones, in 1889, was written, and consequently no additional results had been obtained.

Ice and heavy freshets had brought into the river channel a number of great bowlders, which were an additional annoyance and danger to boats navigating the river.

Although the work heretofore done on the river has been very beneficial to navigation by lessening its dangers, it has not increased the navigable depth and capacity, particularly of the Snake River.

As stated in Maj. Jones's report, the general result of all work done and of natural forces at work has been to lower the bed of the river about 1½ feet; but it is found that the water surface has also been lowered, so that the resulting navigable depth is about the same as that which formerly existed.

The amount expended during the fiscal year ending June 30, 1892, was $8,275.04.

Results obtained to June 30, 1892.—During the fiscal year ending June 30, 1892, a large amount of work was done in removing bed rock and bowlders from the river between Riparia and Lewiston. The total amount of rock removed was 293 cubic yards. The removal of this was of very great benefit to navigation, permitting the boats to carry more than double the loads that they could have carried without the improvement and with greater safety.

Report of operations.—Mr. W. H. Wood was placed in charge of the work on the Snake, and left Portland August 6, 1891, and proceeded to Riparia, where the drill scow constructed the previous fiscal year was moored.

A crew and full outfit of tools and supplies were secured, and on August 28 the work commenced.

The plan of the work was to go from point to point up the river, stopping long enough at each bad place to remove the worst and most dangerous rocks. The drill scow was towed from point to point by the steamers plying on the river.

Capt. Baughman, who has had charge of the steamers running on the river, was engaged to designate the points where work was most

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needed and to buoy the rocks of which the removal was most desirable. His practical and close knowledge of the river, gained by running on it at all stages for many years, was of the greatest benefit to the work, enabling more to be accomplished for the benefit of navigation with the same expenditure of time and money than could have been accomplished by any other method.

The work continued until November 28, 1891, when the scow was made fast in winter quarters at Selkirk's old ferry, 6 miles below Lewiston.

After this several days were spent in repairing the old crib at Log Cabin Rapids, and everything about the scow was made snug, and Mr. Wood returned to Portland December 15, 1891.

Recommendations and remarks.—Attention is invited to my last annual report under this head (p. 3212, Report of Chief of Engineers).

The only portion of the section of river under consideration which is navigated is the Snake, from Riparia to Lewiston. Upon this portion of the river is transported a large amount of grain, and it furnishes at present the most convenient line of travel for a great section of country.

In this section of the river are many rapids, swifts, and shoals, where work is necessary to secure the best available water. During periods of high water great bowlders are moved from places where they do no damage to places where they are in the way of steamers, and these bowlders, like snags in some rivers, require to be repeatedly removed.

This work requires yearly attention. A drill scow with an equipment of tools has been provided, which will enable the work to be done cheaply and expeditiously.

Besides this work of rock removal, there are three places between Riparia and Lewiston where other work is necessary. These are at Wild Goose Island, 9 miles above Riparia; Diamond Crossing, 13 miles above Riparia, and Log Cabin Rapids, 38 miles above Riparia.

At Wild Goose Island the river is very wide and a number of gravel islands have been formed, which divide the waterway into a number of channels, which at low water become very shoal, crooked, and swift.

At low water now steamboats are compelled to use the south channel, shown on the plat. This is crooked and shoal above the rapid. The straight middle channel becomes worse than the south channel at low water and can not be used. It is proposed to overcome the difficulty by building a stone dike across the south channel, as shown on the plat, this dike to extend to 2 feet above low water. This, it is believed, will force the water through the middle channel, thereby scouring it to greater depth, lengthening the rapid and lightening the current.

The estimated cost of this dike is $8,068.50.

At Diamond Crossing there is a long shoal extending diagonally across the river, covering a distance of a half mile in the length of the river. The river is wide, the current light, and there is no defined channel. The present line of steamboat channel is very hard to navigate. The boats have to drift nearly across the river in very shoal water, which in windy weather makes it extremely difficult to keep from being driven on the bars.

It is here proposed to build a stone dike 750 feet long to a height of 2 feet above low water from the end of the gravel bar on the south side out into the stream, and thus force the water around same. This it is believed will give a narrower and deeper channel.

The estimated cost of this dike is $9,330.75.

At Log Cabin Rapids the river divides into two channels—the north

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and south. Steamboats use the south channel, the north one being crooked, and with the fall so concentrated as to prevent boats going up it without lining. The south channel is only 4 feet deep in places at low water, and is constantly getting shoaler. It has a current of 6 miles per hour. The channel is full of bowlders and large gravel and is so narrow and crooked that in windy weather it is hard to navigate.

It is proposed to remedy the difficulty at this point by building a stone dike 500 feet long to 2 feet above low water, closing up the north channel and thus forcing the water at low stages through the south channel, giving a greater volume, which it is believed will both deepen and widen it.

The estimated cost of this dike is $5,810.75.

At this point there is a crib work built of timber and filled with stone, the object of which is to prevent boats drifting downstream from running on the rocky shore. This crib should be extended 50 feet farther downstream to more perfectly fulfill its mission.

The estimated cost of this extension is $1,016.63.

Plats showing the three bad places above mentioned and the proposed improvements are herewith.

The amount of money recommended for the next fiscal year is as follows:

Removing bowlders, rocks, etc	$5,000.00
Building dike at Wild Goose Island	8,068.50
Building dike at Diamond Crossing	9,330.75
Building dike at Log Cabin Rapids	5,810.75
Extending crib	1,016.63
Total	29,226.63

In round numbers, $30,000.

It is further recommended that the appropriation be made available as far as Asotin, above 7 miles above Lewiston, for reasons set forth in my letter of December 21, 1891, and published in House Ex. Doc. No. 77, Fifty-second Congress, first session.

Report of Mr. W. H. Wood, the assistant engineer in personal charge of the work, is herewith:

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 24, 1891.

CAPTAIN: I have the honor to submit the following report of the work of improving the Snake River between Riparia, Wash., and Lewiston, Idaho, during the months of August, September, October, November, and December, 1891.

According to your verbal instructions I was placed in charge of this work August 1, 1891. I left Portland August 6 and proceeded to Riparia; thence to Lewiston.

I found the work most necessary to be done was the removal of numerous rocks or bowlders which had been carried down by ice and high water and deposited on the bars and shoals, thereby obstructing navigation very much, as they invariably lay in the deepest water, thus causing the boats to leave the channel to avoid same.

The United States drill scow *Tacoma* was tied up at Riparia in charge of Capt. E. W. Baughman. The same was turned over to me August 13, at which time the water in the river was 3 feet above low water, but falling rapidly.

It was deemed advisable to delay the work some days awaiting lower water. A part of a crew of men who were hired in Pasco, Wash., arriving at Riparia August 19, were put to work repairing and equipping the scow, taking aboard provisions, wood, etc. This work continued until August 28, when, having secured a crew of 10 men and the river having fallen to 1 foot above low water, I started to tow the scow up the river.

Arrangements had previously been made with Capt. Baughman to have the steamer *Annie Faxon* tow the scow from point to point as required.

Owing to high winds the steamer was unable to tow, and the scow was landed 1 mile above Riparia, from which point it was lined to Little Goose Island, 3 miles away, which consumed four days.

The actual work of drilling began here on September 3 and progressed until September 12. Forty-two and one-half linear feet of holes 2 inches in diameter were

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drilled in seven bowlders. The holes were fired and the bowlders completely broken up. Several smaller bowlders were also removed by grappling tongs. A channel was thus secured 100 feet wide, with a minimum depth of 3½ feet at low water; stage of water, +0.25. (All stages of water referred to Union Pacific Railroad gauge on abutment of railway bridge at Riparia.)

September 14, towed by steamer to mouth of Deadmans Gulch, 18 miles above Riparia. Here two large bowlders lay directly in channel. Four holes, each 3 feet deep, were drilled, loaded, and fired, and the bowlders completely removed.

September 18, towed from Deadmans Gulch to a point 2 miles above Almota, and 37 miles above Riparia. One large rock lay in channel here. Four holes, each 3 feet deep, were drilled and fired and the rock completely broken up, thus giving 6 feet of water at low-water stage.

September 20 and 21, the scow was being lined from the above point to rapid at Log Cabin Island, 4 miles above, where several bowlders lay in channel, and a small gravel bar formed at the lower end of the rapid was obstructing the channel. The rock was removed by the usual process of drilling and blasting. Twenty-two feet of holes were drilled in four rocks, which, when fired, were completely removed. A number of smaller bowlders were picked up and broken or removed from the channel.

The gravel bar was blasted by driving 3-inch iron gas pipe to a depth of 5 feet in gravel, and when heavily loaded and fired the gravel was so loosened that since that time the current has washed the greater portion away.

September 24, towed from Log Cabin Island to Kelleys Bar, 23 miles below Lewiston, where one large rock, submerged 2 feet, was directly in the channel. Nine feet of holes were drilled, loaded and fired, breaking up rock and leaving a depth of 6 feet at low water.

September 25, rafted scow 4 miles down the river to Truax Landing, where one bowlder lay in channel. Two holes, each 3 feet deep, were drilled and fired, completely removing the bowlder. Owing to a slight accident caused by the parting of a line, one of the spuds on the scow was broken and we lay at Truax Landing repairing the same until October 1, when the steamer towed the scow to Little Pine Tree Rapid, 13 miles below Lewiston. Here a quantity of work was to be done. Just above the rapids the river is wide and shoal, and what small channel there was was so obstructed by submerged bowlders that it was very difficult for boats to get through.

About 80 of these bowlders were removed. One hundred and three and one-half linear feet of drilling was done in thirty-nine holes, which were fired with good results, while a number of the smaller rocks were picked up with a derrick and tongs. There now remains a clear straight channel 150 feet wide, with a least depth of 5 feet at low water, which the river boats now go through without difficulty.

October 18, in tow of the steamer, we moved to Lewiston, where from this date until November 19, our time was spent in removing bowlders in this vicinity.

A total of 194½ feet of holes were drilled and all holes fired, and 132 cubic yards of rock removed by blasting, and a large number of small rocks removed with derrick and tongs, so that at present boats can load at Lewiston with 2,500 sacks of grain, where formerly 1,000 sacks were all they could get out with.

November 21, rafted scow down river to a bar 4 miles below Lewiston, and there removed one large rock from the channel. Three holes, each 4 feet deep, were drilled and fired with good results, and there is now 8 feet of water over the rock.

A heavy wind storm of three days' duration held us here unable to move. All through this work considerable time was lost on account of the wind, which frequently blows a gale. At such times we were not able to move or work.

November 28, the scow was rafted to winter quarters at Selkirk's old ferry, now known as Evans, 6 miles below Lewiston.

Repairing crib.—At Log Cabin Island a crib had formerly been built to aid in navigating the channel at that point, but it had been damaged to some extent by high water, and according to your instructions, I was to repair the crib. I purchased sufficient lumber at Lewiston, and on November 28 I started with lumber, raft, and men to repair the same, and reached the work the same day. The Union Pacific Company allowed me the use of their scow which lay at that point to live on. The weather turned very stormy and this work was not completed until December 8.

Following is a statement of the cost of the same:

Lumber	$99.36
Labor	159.80
Iron bolts, etc	11.45
Subsistence	56.79
Total	327.40

Having completed the above work and returned to the scow at Evans, and made some needed repairs, painting roof, etc., I took an inventory of all equipment; discharged all the men December 12, and returned to Portland December 15, 1891.

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Much valuable aid was given me by Capt. E. W. Baughman (who has navigated the river for years) in pointing out all the obstructions, many of which otherwise might have been overlooked, and in many instances marking with buoys rocks that were hard to discover, and otherwise aiding in the work to a great extent.

All the equipment of the scow was stored on the scow which was locked up and the keys left with Capt. Baughman, who now has charge of the scow, together with a quantity of powder that was left at Little Pine Tree Rapid.

The stage of water throughout this work was very uniform, never varying more than 1 foot from zero of gauge at Riparia, twice becoming a little muddy, but soon clearing again.

Summarized statement.

Total expenditures:	
Labor	$2,571.60
Equipment	479.08
Supplies (work)	813.09
Supplies (subsistence)	1,013.83
Repairs to boat	60.62
Towing boat	50.00
Engineering	659.05
Total	*5,647.27

Summary of work:

Work began August 19, 1891.

Work ended December 12, 1891.

Labor performed	days..	1,318
Holes drilled	linear feet..	416
Holes drilled	number..	136
Holes fired	do....	129
Explosives used	pounds..	1,434
Rock removed	cubic yards..	293

Cost of rock per cubic yard, $15.43.

All labor was hired by the month and board furnished.

Future work.—The removal of bowlders from the channel of the Snake River should have yearly attention. From the reports of captains of the river steamboats the ice and high water carry down and deposit these bowlders in the channel each year.

Estimated cost of this work yearly, $5,000.

Aside from the above there are three places in the river between Riparia and Lewiston that I think could be greatly improved if the expenditure were deemed advisable.

(1) Wild Goose Island, 9 miles above Riparia: Here the river is divided into three channels, and shoals badly in each at the head of the island. Steamboats now go through the south channel, which is very crooked and shoal above the rapid. The middle channel is the straight one, but its present disadvantage is that it shoals at head of rapid, which shoal at low water grows worse, shortening up the rapid and forming so strong a current that steamers have to line over the same.

I would suggest a stone dike, 900 feet long, at 2 feet above low water, as shown on the sketch, closing up the south channel and forcing the water through the middle channel, thereby scouring it to a greater depth, which would also tend to lengthen the rapid and lighten the current, as the shoal is composed of loose gravel, which will be easy to scour.

Estimate: 2,934 cubic yards rock, at $2.75 per cubic yard in place, $8.068.50.

(2) Diamond Crossing, 13 miles above Riparia: This is a long shoal extending diagonally across the river, and about a half mile in length. The river at this point is wide and the current light, with loose gravel bottom and no defined channel. It is here proposed to build a stone dike 750 feet long, 2 feet above low water, from the end of the gravel bar on the south side out into the stream, and force the water around the same, thereby forming and maintaining a more contracted channel on the north side of the river, which it is believed would scour a deeper channel.

The present line of the steamboat channel (see sketch) is very hard to navigate. Steamers have to drift nearly across the river in very shoal water, which in windy weather makes it difficult to keep from being driven on the bar.

Estimate: 3,393 cubic yards rock, at $2.75 per yard in place, $9,330.75.

(3) Log Cabin Rapids, 38 miles above Riparia: Here the river divides, forming north and south channels. Steamboats use the south channel, the north one being so rapid as to always cause them to line, and it is also very crooked. The south channel is only 4 feet deep at low water in many places, and constantly getting shoaler. It has about a 6-mile current.

The bottom is composed of bowlders and large gravel, and the channel follows the

*This does not include the cost of the drill scow.

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south shore closely and is so narrow and crooked that in windy weather it is hard to navigate.

I would suggest a stone dike 500 feet long, built to 2 feet above low water, closing up the north channel and forcing all the water through the south channel, giving a greater volume of water which I believe will both deepen and widen the same.

Estimated: 2,113 cubic yards rock, at $2.75 per yard in place, $5,810.75.

At this place I would also recommend the extension of a crib, same as is shown on south shore in sketch and used as a sheer for steamers.

This needs to be extended about 50 feet on the west end. To be built of rough lumber and filled with suitable rock.

Estimated cost complete: $1,016.63.

Summary of future improvements.

Removing bowlders from channel yearly	$5,000.00
Building dike at Wild Goose Island	8,068.50
Building dike at Diamond Crossing	9,330.75
Building dike at Log Cabin Rapids	5,810.75
Extension of crib	1,016.63
Total	29,226.63

The above to include cost of plant together with placing of rock.

Very respectfully,

W. H. WOOD,
Assistant Engineer.

T. W. SYMONS,
Capt., Corps of Engineers.

Future operations.—Future operations with the money available will consist in placing the drill scow in commission, and removing rocks and bowlders. This work can only be done advantageously when the river is low and the water is clear, which is from about September 1 to December 1 each year.

Money statement.

July 1, 1891, balance unexpended	$16,557.77
June 30, 1892, amount expended during fiscal year	8,275.04
July 1, 1892, balance unexpended	8,282.73
July 1, 1892, outstanding liabilities	25.00
July 1, 1892, balance available	8,257.73
Amount appropriated by act approved July 13, 1892	15,000.00
Amount available for fiscal year ending June 30, 1893	23,257.73
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

COMMERCIAL STATISTICS.

The following information is furnished by Capt. B. R. Pegram, superintendent, Water Lines, Union Pacific System:

Shipping.—Steamers operated by Union Pacific Railroad upon Snake River between Riparia and Lewiston and intermediate points during fiscal year July 1, 1891, to June 30, 1892, with tonnage, draft, and amount of freight carried:

Name.	Registered tonnage.	Draft.	Freight carried.
		Inches.	*Tons.*
Steamer Annie Faxon	564	22	9,029
Steamer Spokane	531	20	5,594
Steamer Almota	395	18	4,544
Total			19,167

Total value about $600,000.

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T T 9.

IMPROVEMENT OF COLUMBIA RIVER BETWEEN HEAD OF ROCK ISLAND RAPIDS AND FOOT OF PRIEST RAPIDS, WASHINGTON.

Description of original condition.—The portion of the Columbia from the head of Rock Island Rapids to the foot of Priest Rapids is about 60 miles in length. The river flows generally through a deep cañon. The banks for the greater part of the way are nearly precipitous bluffs from 1,000 to 3,000 feet high, composed of columnar black basalt. The country bordering the river is rocky and sterile.

The three principal obstructions to the navigation of this portion of the river are Rock Island, Cabinet, and Priest rapids. At Rock Island Rapids the river has cut around both sides of a large island of rock. The channel, however, on each side is very much obstructed with reefs, rocks, and points sharply projecting from the shore. The result is a waterway so much restricted at all stages as to dam up the waters to such an extent that they escape over lines of very steep slope and amidst great masses of reef, rocks, and high projecting islands. A great reef is found a short distance above the head of the island which has caused extensive deposits of gravel, nearly choking the channel at low water.

The river here has a fall of 10 feet in 3,000 feet, and 12½ feet in 8,000 feet, at a stage as nearly as can be ascertained of 4 feet above low water.

At Cabinet Rapids a mass of basaltic rock projects from the left shore nearly two-thirds across the channel of the river, deflecting the current and causing it to impinge upon the nearly vertical basaltic rocks of the right bank. Other masses of rock exist in the channel in and about the main rapids. The fall here is 10 feet in a distance of about 8,000 feet.

At Priest Rapids there are seven principal rapids extending over a length of 10 miles of river.

The total fall in this distance is, at low water, 72 feet, and at high water about 63½ feet.

In all these rapids the river runs through and over hard, rough, and jagged basaltic rocks.

Plan of improvement.—The plan of improvement under which existing work has been carried on consists in removing obstructing rocks at Priest, Cabinet, and Rock Island rapids, and putting in at all locations where they would be convenient, iron posts and ring bolts, to which ascending boats could make fast their lines and then wind themselves up over the rapids by means of their steam capstans, with which all such boats would naturally be provided.

The estimated cost of the work proposed was $550,000.

In addition to this it was proposed to continue the survey of the Columbia from the head of Rock Island Rapids to the boundary line. This project was approved by the Secretary of War October 18, 1890.

APPROPRIATION.

Act of September 19, 1890 ..... $70,000

Of which $10,000, or so much thereof as may be necessary, may be used in the survey of the Columbia River from the international boundary line to Rock Island Rapids.

The amount expended to end of fiscal year June 30, 1891, was $31,291.13.

For survey of river from international boundary line to Rock Island Rapids. $2,691.91
For improvement of river at Priest, Cabinet, and Rock Island rapids 28,599.22

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Results obtained to June 30, 1891.—The following extract from my last annual report shows the condition of the work to June 30, 1891:

The work so far done on the river at Priest and Cabinet rapids has not produced any results of a marked nature. All rocks removed tend to the final result and would benefit and render safer navigation on the river if there was any navigation, which there is not.

The survey of the river from the international boundary line to the head of Rock Island Rapids has progressed under Mr. William Cuthbert, so that the work is nearly done from the boundary line to the mouth of the Spokane.

The total amount expended during the fiscal year ending June 30, 1892, was $28,195.29, of which there was expended for survey of river from international boundary line to Rock Island Rapids $7,227.95, and for improvement of river at Priest, Cabinet, and Rock Island rapids, $20,967.34.

Results obtained to June 30, 1892.—The work of improvement during the fiscal year has been confined to Cabinet and Rock Island rapids.

At Cabinet Rapids a number of projecting points along the right bank have been removed, and some rocky island masses near the left bank were honeycombed with drifts and drill holes, loaded with dynamite, and blasted, dividing the rock into small fragments which it is expected will be washed away at high water.

If this is the case, Cabinet Rapids will be improved to as great an extent as appears necessary in the way of rock removal.

A number of ring bolts have also been put in at various points along the river for convenience of boats in lining over the rapids, if any should attempt it.

The work at Rock Island Rapids has been conducted with the object in view of removing obstructions which existed to boats lining up along the right bank during the higher stages of the river, and which endangered boats in running down.

That which has been done at both Cabinet and Rock Island rapids would be of great benefit to navigation if any existed.

Report of operations.—At the beginning of the fiscal year the operations in progress in connection with the improvement were the taking of the drill scows up to Cabinet and Rock Island rapids. On July 17, 1891, the foot of Cabinet Rapids was reached, and on July 31 the boats had been lined over the rapids and taken to Moses Coulee Ferry, between Cabinet and Rock Island rapids. The high water continuing, work on rock removal was not commenced until September 10. Upon this latter date operations were resumed on Cabinet Rapids and continued until February 15, 1892, with an average daily force of thirty-six and one-half men.

During this time there was used at Cabinet Rapids 11,050 pounds of dynamite No. 1; there were drilled 472 2-inch holes, aggregating a length of 3,002 linear feet, and twenty-two drifts were run to a total length of 410 feet. The last blast was February 12. The result of the work was the removal and breaking up of 12,199 cubic yards of rock. That which was not fully removed it is expected will be removed by the high water.

On February 25 work was commenced on Rock Island Rapids, and continued until May 5, with an average force of fifteen men. During this time there was removed rock aggregating 1,894 cubic yards; 256 holes 2 inches in diameter were drilled to a total length of 1,414 feet.

A permanent gauge was erected at Rock Island Rapids.

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On May 5 the boats were taken back to Moses Coulee Ferry, tied up, and left in charge of a watchman.

The tracings sent herewith show the work which has been done at Cabinet and Rock Island rapids.

Recommendations and remarks.—I desire to invite attention to the statements under this head in my last annual report on the "Upper Columbia from the head of Rock Island Rapids to the foot of Priest Rapids," and the "Upper Columbia and Snake," pages 3226 and 3212, Report of Chief of Engineers, U. S. Army.

If the work on the project is to proceed, the amount of money which can be profitably expended the next fiscal year is $50,000.

Future operations.—As there is a practical certainty that there will be no further appropriation at present for the improvement of this stretch of river, no further operations of any magnitude are mapped out.

With the money remaining on hand, it is expected to take care of the plant, and if authority is granted it is expected to use the boats and tools in the improvement of the Snake River, for the improvement of which provision is made in the river and harbor bill.

The report of Mr. J. G. Holcombe, in charge of the work, is herewith.

Money statement.

July 1, 1891, balance unexpended		$38,708.87
June 30, 1892, amount expended during fiscal year:		
Improvements	$20,967.34	
Survey	7,227.95	
		28,195.29
July 1, 1892, balance unexpended		10,513.58
July 1, 1892, outstanding liabilities		25.00
July 1, 1892, balance available		10,488.58

REPORT OF MR. J. G. HOLCOMBE.

PORTLAND, OREGON, *June 30, 1892.*

SIR: I have the honor to submit the following annual report of the operations upon this work under your charge for the year ending June 30, 1892:

At the close of last year work at Priest Rapids had been abandoned and the drill scows were being lined to Cabinet Rapids, 54 miles above Priest Rapids.

On June 30 they had been taken to a point about 13 miles below Cabinet Rapids, and July 17, having reached the foot of them, I built a magazine and placed the dynamite in it. The scows were then lined through the rapids and on July 30 we finally reached the head, having been considerably delayed during the entire period of moving the boats from Priest Rapids by the high winds that blow down the river during the summer months.

Having reached the head of the rapids I hired the steam ferryboat *Rattler* to tow the boats to her landing at Moses Coulee, where they were to lie until the river fell sufficiently to permit work on Cabinet Rapids.

As there were no steamers upon this section of the river (between Priest and Cabinet rapids), the moving of the boats had to be by hand. Horses were not available, except for a short distance, because of the rough and precipitous character of the banks.

Having reached the ferry landing on July 31, I laid off 5 men and dispensed with a special mail-carrier who had been employed since March 1 to bring official mail twice a week from Ellensburg, the nearest post-office to the river, and on the 15th of August, after the visit of inspection by Col. Mendell and yourself, I laid off 2 more men, keeping 3 men to finish certain repairs to the plant.

On the 22d of August I left for Ellensburg to engage miners in anticipation of the river being low enough by the 10th of September to resume work at Cabinet Rapids.

On that date the drill scows were dropped down stream to the rapids and work again commenced.

Plan of improvements.—The project upon which this work has been done was recommended by you as a modification of Maj. W. A. Jones's project, and it consisted of the removal by blasting of the worst rocks obstructing navigation and the placing of ring bolts and deadmen, to which the steamers could make fast and line themselves over by means of their steam capstans. This was recommended, not as a permanent improvement, but as an aid that would become at once available to any steamer that might desire to use this stretch of river.

Cabinet Rapids.—During the previous year a small force was sent from Priest Rapids with small boats and tools to blast away certain points and a reef along the right bank at this place. This force worked from April 15 to May 15 and succeeded in blasting at points (marked on the map) H, I, K, and the reef G. On May 15 this work had to be stopped because of the high water.

As the river fell during the year, it was found that the high water had carried away all of the débris of last year's blasting, leaving in most instances a clean rock bed at or below the low-water level.

The work of the present year was commenced by the removal of the point F, which was cut down as low as the then stage of the river would permit. After this was completed work was started upon the mass of rocky islands in the right-hand channel, and the rocks A, B, C, D, N, O, and P have been blasted down to and below the low water of this year.

The rocks B, C, D, P, and parts of A and E were blown up by the usual method of drilling 2-inch holes down to the low-water level, loading with dynamite, and firing by electricity. For the rest, parts of A, E, N, and O, drifts were driven in on the low-water level, these drifts charged and tamped, and then fired by electricity, thus shattering the rock. This method was used in every case where feasible and when the dimensions, especially in height, would allow, and proved a quick and cheap method of blasting the larger rocks.

Results.—As previously stated, the débris of last year's work here had been washed away by the high water.

During this year there have been blasted on three rapids 12,199 cubic yards of basalt rock, using 11,050 pounds of dynamite. To blast this quantity of rock, 472 2-inch holes were drilled, having a total linear measurement of 3,002 feet. There were also driven twenty-two drifts, having a total linear measurement of 410 feet, and one shaft measuring 10 feet to low water, from which three of the above drifts were driven.

The last blast at this rapid was on February 12, when the rock E, containing 6,445 cubic yards was blown up, thus completing the project of rock-blasting at these rapids.

I then had three sets of ring bolts placed at convenient points for ascending steamers to make fast to and line themselves up over these rapids.

The work at Cabinet Rapids extended during this year from September 10, 1891, to February 15, 1892, during which period 6,103 days of labor were expended upon the rock work; this includes Sundays and holidays, upon which no work was done, but which are here included because the force were all employed by the month and subsisted. This employment of labor by the month was necessary because of the comparatively short seasons of good weather in which work could be done, making it necessary to work early and late to accomplish any valuable results.

The average daily force employed during this period was 36.54 men, the largest force 43 men, the smallest force 15 men. On January 31 the force was reduced from 43 to 15 men, this being as large a force as could be conveniently employed at the then existing state of the work.

The work of drilling, etc., was carried on upon one hundred and thirty-four different days, and having a mild winter no time was lost by bad weather.

Debris.—All of the rock is broken small and it is expected that the coming high water will wash considerable of it away.

Condition of the rapids.—While this rapid has at all stages of the river rough water, still steamers, it is believed, can pass them in safety by using the channel along the left bank in high water and the channel along the right bank in medium and in low water. It has been this medium stage that has been the impassable one at this place.

Future improvements.—It is believed that the work already carried out at these rapids is all that is required for the near future, and until the surveys of the upper river are completed and a final scheme of improvement adopted no further work will be required.

Rock Island rapids.—On the completion of the operations at Cabinet Rapids, the drill scows were lined to Rock Island Rapids. We left Cabinet Rapids on February 15, and on the 25th of the same month we reached Rock Island Rapids. A slight delay was caused at the Nixon Rapid by the low stage of the river, and we lost

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about 400 feet of 4½-inch line by one of the small boats swamping. Beyond this, no damage was done.

Plan of improvements.—For Rock Island Rapids, the plans were the same as for Cabinet Rapids, but, on account of the short time before high water, I was directed to confine the work as far as possible to opening a channel through which boats could be lined on an upgoing trip.

On February 25, drilling was commenced and continued until May 5; the first work started was the removal of rock T (see map); this was followed by the clearing of the reef between the right bank and rock O, the blasting of a part of rock O that nearly closed this channel at its head, and the blasting of the point S. While this work was being carried out, I received information that the steamer *City of Ellensburg*, then tied up above Rock Island Rapids, was to be placed in commission and run between Port Eaton (below Cabinet Rapids) and the Okanogan River, some 80 miles above Rock Island Rapids.

I then, at the request of the owners of the steamer, removed as much of the point R and rock *e* as the rising river would permit, so as to give as straight channel as possible for the descending steamer.

After blasting all the rock possible this season, I placed ten sets of ring bolts at all feasible points for use of ascending steamers.

Results.—At Rock Island Rapids, 1,894 cubic yards of basalt rock have been blasted using 1,325 pounds of dynamite. To blast this quantity of rock, 256 2-inch holes were drilled having a total linear measurement of 1,414 feet. As stated above, the work at Rock Island Rapids extended from February 25 to May 5, 1892, during which period 1,173 days' labor were expended, including Sundays and holidays; 115 of these were employed in moving the plant from Cabinet Rapids.

The average daily force employed upon this work was 15 men.

Having completed all that could be finished before high water on May 6, 1892, I dropped the drill scows back to the Moses Coulee Ferry Landing, where they are to lie during high water.

On the 7th instant I paid off and discharged most of the force, and on the 11th, having packed all tools and equipment away and cleaned the boats, I paid off the rest of the force and, leaving a watchman in charge of the scow, I reported to you at the Portland office.

Before leaving Rock Island I erected a permanent river gauge reading from low water this year to 40 feet above.

Condition of plant.—During the last month of the work at Rock Island Rapids I employed a carpenter, who was engaged in repairing and painting all the small boats used upon this work and the survey of the upper river, which had been left with me when that survey was stopped. These boats (seven in number) have been placed in good order and the entire plant is in good condition, with the possible exception of lines and oars, the work in the rocky channels having been the cause of breaking and losing a quantity of these articles.

Future improvements.—This rapid is still a dangerous one for boats to pass down over. I would recommend the removal of rocks *a*, *b*, *c*, *i*, *k*, and a part of rock *o*, and U, V, and R, so as to give a safe channel for boats to descend during high and medium water. This work can be done in a single season and would afford relief while the permanent improvements are being planned and carried out upon the upper river.

In this connection I deem it right to call attention to the fact that the Great Northern Railroad is now building along the left bank of the river from below to a point above Rock Island Rapids, where it will cross the river on its way to the Pacific Ocean, thus forming an outlet to this upper country above Priest, Cabinet, and Rock Island Rapids. The only other railroad that now reaches the river below Kettle Falls is the Northern Pacific, crossing at Pasco, but this place can not be made available as an outlet for the upper country until such time as the improvement of Priest Rapids is carried out. There is a possibility of a railroad being built from Ellensburg, on the Northern Pacific, to Port Eaton. If this road is built it will be for the purpose of developing the steamboat trade upon the upper river, and then the clearing of Rock Island Rapids becomes of vital importance and the clearing of them would be for the benefit of that stretch of country that is now without any permanent connection with the marts of this coast.

This and Priest Rapids will always be a difficult place for boats to pass over until either a system of locks or boat railways are built at these places, because of the great fall that takes place in the river profile at these points, and until such time as the obstructions at the Dalles and the Cascades are overcome, the steamboat traffic upon this river will be in connection with the railroads.

Priest Rapids.—During the past year no work of any sort was carried out at this place, work having stopped before the end of last year.

Commerce.—During the past year there were no steamers or other vessels navigating this stretch of river. On the 1st of May the *City of Ellensburg* was placed in commission and began to make two trips a week from above Rock Island to the Okanagon River.

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It is not out of place to call attention to the fact that this boat passes over all the riffles and rapids to, and including the Methow, without the use of lines, and before this boat was overhauled she lined at six different places on the route.

The building of the Great Northern Railroad has called renewed attention to this large section of country, and settlers are coming in from all points.

During the past year the fall of the river from high to low water at Moses Coulee Ferry was 40 feet, the low water uncovering rock *c*, at the foot of Rock Island Rapids, which I am informed had not happened for five years.

Visits of inspection have been paid to this work by Col. Mendell, yourself, Lieut. Fitch, and Lieut. Shunk.

There were also taken during the month of September, 1891, photographic views of Cabinet and Rock Island rapids, which have been transmitted to you.

Accidents.—During the past year there has been no accident or other mishap of a serious nature.

Very respectfully, your obedient servant,

J. G. HOLCOMBE.

Capt. T. W. SYMONS,
Corps of Engineers.

SURVEY OF THE COLUMBIA RIVER FROM THE INTERNATIONAL BOUNDARY LINE TO THE HEAD OF ROCK ISLAND RAPIDS.

The amount expended on this work to June 30, 1891, was $2,691.91, with the result of nearly completing the survey from the boundary to the mouth of the Spokane River.

The amount expended during the year ending June 30, 1892, was $7,227.95, making the total amount expended on the project to the latter date, $9,919.86.

The work has been practically completed as far as the mouth of the Okanogan River. The maps, plans, and profiles of the river, as far as surveyed, are well under way, and will be completed in a short time.

Report of operations.—At the beginning of the fiscal year the party under Mr. William Cuthbert engaged on the survey, were in camp at the mouth of the Spokane, working up their notes and awaiting the subsidence of the waters.

On the 13th of July they started from camp and went back to the boundary line and commenced a line of levels which had not been taken in first traversing the river, and getting the topography, soundings, etc.

From the mouth of the Spokane down, the line of levels was run at the same time with the other survey.

Twenty-eight bench marks were cut in the solid rock, and one was marked on a cedar post where the survey terminated at the mouth of the Okanogan. (A list of these bench marks is given in Mr. Cuthbert's report.)

The latter part of August the running of the levels had been completed and the party were again in camp at the mouth of the Spokane.

It was not until September 26 that the river had fallen to a stage fitted for the work of continuing the survey. Upon this date Mr. Cuthbert with his party of eleven men started from the mouth of the Spokane and the field work of the survey continued until December 20, when the Okanogan was reached. The party then proceeded down the river, some of the men leaving at Wenatchee, until the drill scows at Rock Island Rapids, under Mr. J. G. Holcombe, were reached. Here were left the boats, camp outfit, etc., and after discharging his men, Mr. Cuthbert came on to Portland and has been at work ever since in platting his work.

In making this survey, the topography has been worked in by stadia, and connection has been made, wherever possible, with land office stakes;

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the levels have been run by means of a regular Y level and the soundings taken in the ordinary manner with lines and poles, located by the stadia and cross sights.

Besides the instrumental survey which forms the basis for the map, a large number of photographs have been taken all along the river from the boundary line as far as the survey has progressed. These photographs are particularly of the bad places in the river.

There were taken seventy-one views from the boundary to the Spokane, and forty-four from the Spokane to the Okanogan. Of these views, eighty-nine in quintuplicate were sent for exhibition at the World's Fair at Chicago. There were also sent with these fifteen photographs in quintuplicate, of Priest, Cabinet, and Rock Island rapids.

It is believed that a very correct idea of the river can be obtained from the maps, profiles, and these photographs.

At a number of places the river was gauged.

Near Marcus, which is just above Kettle Falls, the measurements were made at a stage of 8 feet below high water, and gave a discharge of 196,000 cubic feet per second. By allowing for an increased height of 8 feet to bring the river up to high water and with the observed rate of current, the discharge is 250,000 cubic feet per second.

At Rickeys, below Grand Rapids, the measurements were taken at a stage 6 feet above low water, and gave a discharge of 112,000 cubic feet per second. Taking 6 feet in elevation away from the cross sections gives a discharge at low water of 53,000 cubic feet per second.

As the velocity at high water would undoubtedly be increased over the velocity measured at 8 feet below the high-water stage, and the velocity at low water would be decreased below that observed at a stage 6 feet above low water, it may be taken as an approximate general summary that in this upper part of its course, the Columbia has a low-water flow of about 50,000 cubic feet per second, and a high-water flow of about 300,000 cubic feet per second.

The total length of the Columbia from the boundary line to the mouth of the Okanogan was found to be 214 miles, and in this distance the fall was found to be 524.4 feet, being an average fall per mile of 2.5 feet. The average fall from the boundary to the Spokane is 2.2 feet per mile and from the Spokane to the Okanogan is 2.8 feet per mile. In the stretch of possibly navigable water from the Okanogan to Kettle Falls the fall is 1.97 feet per mile, and from below Grand Rapids to the Spokane the fall per mile is 1.62 feet.

As nearly as can be ascertained the average velocity of the water from the boundary line to the Okanogan is 3.48 miles per hour.

The maximum velocity observed was at the upper part of the Spokane Rapids, where it was 15.38 miles per hour. There were a number of places where the velocity was found to be 10 to 12 miles per hour. A list of places where the most rapid flow was observed is given in Mr. Cuthbert's report.

Recommendations and remarks.—It is very much to be hoped that this work can be continued until the whole of the Columbia River is surveyed.

It is not probable that this river for its whole length in our territory will ever be used as a through highway of commerce, but unquestionably certain portions of it will be used as feeders to railroads, and thus become of great importance. The survey will enable correct conclusions to be arrived at regarding these portions, the kind of boats necessary and proper to put on, and the improvements which may be necessary to utilize the river for the greatest benefit of the people.

If the amount named in the river and harbor bill now before Congress is appropriated, it will complete the survey to Rock Island Rapids, and no more money will be required for the survey of this portion of the river.

If it does not, I would recommend an appropriation of $10,000 to complete the survey to Rock Island Rapids.

Report of Mr. Cuthbert is herewith:

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, June 3, 1892.

CAPTAIN: I have the honor to report that in pursuance of instructions contained in your letter dated June 17, 1891, "to go back to the boundary line and run a line of levels down the river, * * * " and of verbal instructions received from you at Spokane City on July 2, 1891, I proceeded to camp at the mouth of the Spokane River, and the Columbia River having fallen sufficiently to allow of it, started from there on Monday, July 13, 1891, with four men to tow one of the boats in my charge up to Rickeys Landing, a distance of 55 miles.

This was accomplished by 3 p. m. on Saturday, the 18th, having made an average of 10 miles per day with a loaded boat.

On Sunday, July 19, the boat and baggage was hauled by team to Meyers Siding, a station on the Spokane Falls and Northern Railway, and the boat loaded onto a flat car which had been previously arranged for.

On Tuesday, July 21, started from Meyer's Siding at 5:30 a. m., reaching Corbin's Landing on the Columbia at 10 a. m., where the boat and baggage were transferred onto the steamboat *Lytton*, and the international boundary line was reached at 12:30 p. m.

Bench marks.—Twenty-eight bench marks (a list of which, giving their positions and elevations, is attached) have been cut in the solid rock. The twenty-ninth is a cedar post near the mouth of the Okanogan River. I could not find any rock in that immediate locality.

Levels.—Establishing the elevation of bench mark No. 0 at the international boundary line from the levels of the Spokane Falls and Northern Railway, which are continued from the sea level datum of the Northern Pacific Railway, as 1,356 feet above sea level, I proceeded leveling down river, taking the water surface and all well defined high-water marks. The river at this time was 7 feet below the high-water stage.

Connections with the levels already taken at all important places during the low-water stage were made. (A list of levels and falls is attached.)

On July 30 I got down to Little Dalles. There I had to portage the boat around, as the high stage of water rendered the river unnavigable, and Marcus was reached on Saturday, August 8, 1891.

Soundings.—From Marcus downwards I re-sounded the river, the depths being relative to the water-surface line of levels and a good check on the soundings of the former survey.

Volume of flow.—At a very favorable spot about 2 miles above Marcus, I tested the volume of flow of water. This I have done at several other places and at various stages of water.

All of these, allowing for the different heights of water, compare very well. I pick out two of them, those nearest to high and low waters:

	Cubic feet per second.
At Marcus:	
Eight feet below high water	195,621
Allow 8 feet higher water, but no increase in rate of current, and it will give	249,853
At Rickeys Landing:	
Six feet above low water	112,149
Taking 6 feet in elevation from cross sections, but not reducing rate of current	53,528
This will give an average of	151,690

From this average the flow during the average day would be 13,106,059,200 cubic feet.

Rates of flow.—With a view of ascertaining what rate of speed a steamboat to successfully navigate this river should be capable of, I tested the rate of surface flow in all places where it is quicker than usual.

From these tests and observations of slower currents, I ascertain as nearly as possible that the average rate of surface flow from the international boundary to the

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mouth of the Okanogan River is 3.48 miles per hour. The particular places where the flow is most rapid are as follows:

Names of places.	Miles from boundary line.	Miles per hour.
Pingstone Rapids	81	8.21
For 2 miles above Rogers Bar	80	6
1 mile below Rogers Bar	83	6
Deer Creek	93	7.13
Upper end of Spokane Indian Reservation	97	5
Miter Rock	100	6
Spokane Rapids, upper part	105	15.38
China Rapids	109	12.7
Above Hawk Creek for 4,000 feet	110	11
Below Hawk Creek:		
For 6,000 feet	111	10
For 3,000 feet	112	12
For 3,000 feet	113	10
For 2,000 feet	114	12
Friedlander's store	124	11
Below mouth of Sans Poil River	133	9
Mammoth Spring	136	6
Cayuse Rapid	142	8
Nespilem Rapid	165	7.5
Mah-kin Rapid	175	10.21
Parsons Rapid	182	6.45
7,000 feet below Island Shoal	185	7
Long Rapids:		
First Riffle	190	9.09
Second Riffle	191	10.34
Third Riffle	191	10.58
Eagle Rapids	193	7.35
Foster Creek Rapids	201	6.23
Bend above Port Columbia	211	6

On the evening of Saturday, August 29, I had got to within 2 miles of the head of Spokane Rapids. Here I stopped until I had a full crew, to take cross soundings at frequent intervals above these rapids, so as to determine what the result to this part of the river would be were the bowlders at present causing the obstruction blasted away.

Survey resumed.—The river having fallen sufficiently to allow of the regular survey being gone on with advantage, I recommenced work with a full party of 11 men, including Mr. O. C. Yocum as photographer, on Saturday, September 26, and found that there is very deep water above the Spokane Rapid, ranging from 51 to 69 feet, with a sluggish current of about 2¼ miles per hour.

Hell Gate was reached on Sunday, October 25. At this place, the current at low water is not strong nor would it be hard to navigate; the difficult stages are at middle and high waters on account of the tortuous shape of the channel. If the middle high-water channel was blasted out to low-water level, this trouble would be very much reduced if not done away with entirely.

From this down to Mah-kin Rapid, which in character very much resembles the upper part of Spokane Rapid, the river is comparatively good. Improvements would consist of blasting away lone bowlder rocks, to straighten or widen the channel as the case may be.

Mah-kin Rapid was reached on the 6th day of November. There is a shoal 3,000 feet above it, which I imagine will render it inexpedient to clear out and thereby lower the head of the rapid, but the foot of it could be dammed so as to lengthen and ease the fall and current.

A steamboat to get up here and similar places without lining would have to be capable of making 18 miles an hour in dead water and of keeping up her steam pressure.

On November 24 I got down to the head of Long Rapids in Nespilem Cañon. The lower and narrower part of this rapid is locally known as Box Cañon, the banks on both sides being composed of perpendicular rock 60 to 100 feet in height. At high water it is full of cross currents and whirlpools, owing to the crookedness of the passage. A very large quantity of rock must be removed from the jutting out points all the way through. The low-water depth will average all of 60 feet.

Permanent snow.—Although there was a fall of snow and sleet on November 9, it did not remain. The commencement of permanent snow was on Sunday, December 6. I was then 3 miles above Foster Creek Rapids. From this on, snowstorms and dense fogs greatly impeded the work and rendered it disagreeably cold.

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Foster Creek Rapids at low water is a mass of rocks; 34 can be counted above water, and there is an equal number within 3 feet of the surface.

From this down to the mouth of the Okanogan River, which is 214 miles from the international boundary line, the river is good and navigable at any stage of water.

I finished work at this place on December 20, and proceeded down river with the intention of sending the men to their homes from Pasco.

I arrived at Chelan December 22; went up the lake with Mr. Yocum the photographer, and came down again on the 23d, having obtained sixteen views of this magnificent lake. I left the mouth of the Chelan River on the 26th and arrived at the mouth of the Wenatchee December 29, with a snow storm blowing very hard up river.

From here the Spokane men asked to be allowed to go home; so, retaining as many men (four) as would enable me to handle the two boats. I let the Spokane men go, and with the two boats got down through Rock Island Rapids to the scows in charge of Mr. Holcombe, at Cabinet Rapids, on January 1, 1892.

As Mr. Holcombe informed me that I could not take the boats down through Priest Rapids, I turned over everything I had brought down to him, discharged the four remaining men, and came to this city via Ellensburg, arriving on the 6th day of January, 1892.

Plans, etc.—Since my arrival here I have been engaged in preparing plans and profile of the part of the river surveyed. These are not yet quite completed.

Views of the river.—The photographic work done consisted in seventy-one views of the river being taken at points above the Spokane River by Mr. Warren, and forty-four below the Spokane River by Mr. Yocum, besides the sixteen he took of Lake Chelan.

Very respectfully, your obedient servant,

WM. CUTHBERT,
Assistant Engineer.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

List of bench marks.

Nos.	Positions.	Elevations.
		Feet.
0	On right bank at International Boundary	1,356
1	On left bank at Murphys Rapid	1,333.68
2	On left bank at Steamboat Rock	1,336.56
3	On left bank at Sheep Creek Bend	1,360.35
4	On left bank at Little Dalles	1,335.66
5	On right bank 21 miles from boundary	1,304.64
6	On left bank 27 miles from boundary	1,290.52
7	On right bank at Pingstone Rapids	1,267.58
8	On right bank at Marcus Rapids	1,265.90
9	On left bank at Kettle Falls	1,241.91
10	On left bank at Grand Rapids	1,201.68
11	On left bank at Driftwood Rock Islands	1,193.11
12	On left bank at Gifforda Rocks	1,173.16
13	On left bank at Turtle Rapid	1,157.35
14	On left bank at Spencers Bar	1.168.95
15	On left bank below Rogers Bar	1,151.49
16	On right bank below Elbow Bend	1,148.45
17	On left bank at Miter Rock	1,126.24
18	On left bank at Spokane Rapids	1,116.15
19	On left bank at foot of China Rapids	1,095.69
20	On left bank at Whitestone Rock	1,075.78
21	On left bank at Hell Gate	1,051.24
22	On right bank below Neahkwa Creek	1,020.70
23	On left bank opposite Nespilem River	969.30
24	On right bank at Wild-goose Bills Ferry	947.17
25	On right bank at Gaviota Bend	926.84
26	On right bank at Box Cañon	899.30
27	On left bank at Foster Creek Rapids	853.24
28	On left bank at Port Columbia	817.21

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Memoranda of levels and falls at a low-water stage.

	Elevations.	Difference.	Distance.	Average fall per mile.
	Feet.	*Feet.*	*Miles.*	*Feet.*
International Boundary to Above Kettle Falls	1,305.2 / 1,224.3	80.9	41	1.973
Below Kettle Falls	1,191.2			
Below Grand Rapids to Mouth of Spokane River	1,167.2 / 1,073.4	93.8	57.5	1.614
Boundary to Spokane River		221.4	105.5	2.2
Spokane to Okanogan River		303	108.5	2.8
Boundary to Okanogan River		524.4	214	2.5

COMMERCIAL STATISTICS.

There is no commerce on the portion of the Columbia River between the head of Rock Island Rapids and the foot of Priest Rapids.

From the head of Rock Island Rapids to the Okanogan there is at present one steamer running, and as soon as the Great Northern Railway reaches the river there will probably be others.

Although this stretch of river between the Okanogan and Rock Island Rapids is not that under improvement, it is deemed proper to insert the "commercial statistics" of it as furnished by the Ellensburg and Okanogan Transportation Company.

Steamer *City of Ellensburg*, plying on this route, made seventeen trips during May and June. Her registered tonnage is 85.15, and draft when loaded less than 3 feet.

Amount of freight carried during May and June between Rock Island Rapids and Okanogan River and intermediate points was 238 tons, consisting of general merchandise and lumber.

On the down trip the amount of freight carried was 23 tons, consisting of general merchandise and lumber.

Average number of passengers carried on each trip, 12.

T T 10.

IMPROVEMENT OF CHEHALIS RIVER, WASHINGTON.

Description of original condition.—The portion of the Chehalis River that it is possible to navigate, is about 90 miles in length from Claquato to its mouth. This may well be considered in three sections.

First. From the mouth to Montesano, a distance of 15 miles, there is about 18 feet of water at high water, and coasting vessels traverse this portion of the river.

Second. From Montesano to Elma, 16 miles, the river is slightly affected by the tides, and has in general sufficient water for light-draft boats. But navigation is obstructed by logs and fallen trees, and in summer by a scarcity of water on the bars.

Third. Above Elma the river is practically blockaded during the summer and fall by snags and a general lack of water. At this time the river is a succession of shoals and pools. On many of the shoals the depth is reported to be only from 6 to 12 inches.

Plan of improvement.—The plan of improvement contemplates removal of snags, overhanging trees, dams, drift heaps, shoals, and other obstructions to navigation.

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APPROPRIATIONS.

Act of—	
August 2, 1882	$3,000
July 5, 1884	2,500
August 5, 1886	2,500
August 11, 1888	2,000
September 19, 1890	3,000
Total	13,000

The amount expended to June 30, 1891, was $10,614.60.

Results obtained to June 30, 1891.—During October and November, 1890, 51 snags, 9 trees, 45 piles, 6 stumps, 4 roots, and a quantity of drift were removed from the river between Montesano and Gray Harbor. The river between these places was put into good condition for navigation.

The amount expended during fiscal year ending June 30, 1892, was $100.68.

Results obtained to June 30, 1892.—The river from Montesano to the bay has been kept open and all troublesome snags have been removed.

Report of operations.—During October, arrangements were made with Capt. Tew for the use of the steamer *Aberdeen*, and 3 troublesome snags, averaging 30 feet in length, were removed, and 5 fallen trees, averaging 90 feet in length and 6 feet in circumference, were sawed off and towed out of the channel.

Recommendations and remarks.—Above the town of Montesano there is practically no navigation on the Chehalis except the floating down of logs and an occasional trip of a steamer during high water.

The river between Montesano and the bay is now navigated without trouble by the steamers suited therefor.

A project has been submitted for the improvement of the Chehalis River to allow ocean-going craft to ascend to Montesano. A railroad has been built from Gray Harbor along the Chehalis to Olympia and to Centralia, and is now operated from Aberdeen eastward.

In view of the present good condition of the river from Montesano to the head of the bay, of the special project heretofore submitted for its deepening to permit the passage of ocean ships, and of the railroad now in operation which will still further lessen the importance as a navigable stream of the upper Chehalis, I do not recommend another appropriation for the Chehalis at present.

There is available from the last appropriation $2,284.72, which will suffice to remove any dangerous snags which may appear in the lower river another year at least.

Future operations.—With the existing appropriation it is expected to clear the river below Montesano of snags as soon as they are found to exist and be troublesome.

Money statement.

July 1, 1891, balance unexpended	$2,385.40
June 30, 1892, amount expended during fiscal year	100.68
July 1, 1892, balance unexpended	2,284.72

COMMERCIAL STATISTICS FOR GRAY HARBOR AND CHEHALIS RIVER.

The following returns relative to the commerce of Gray Harbor and the Chehalis River are furnished by Mr. W. B. Mack, secretary, Aberdeen Chamber of Commerce, and are for the fiscal year ending June 30, 1892.

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Vessels arrived and cleared.—The number of vessels of all descriptions crossing in over the bar during the year was 250; the number crossing out was 255.

Most of these vessels are regular traders. The maximum lumber cargo taken out is 950,000 feet, and minimum 200,000 feet. Maximum draft of water, when loaded, 17 feet 6 inches; minimum draft of water, when loaded, 12 feet.

EXPORTS.

Articles.	Quantity.	Value.	Remarks.
Lumber ..... feet, B. M..	75,682,000	.....	
Do ..... tons..	151,364	$1,097,400	
Salmon in bulk ..... do....	(*)	.....	Canneries not running.
Fruit ..... do....	(*)	.....	
Hides ..... do....	210	31,500	
Lath	(*)	.....	Large amount shipped as breakage.
Shingles ..... do....	(*)	.....	Do.
Total	151,574	.....	

* No record.

Lath and shingles are shipped as breakage and no record is kept. The year 1891 was a poor year for the lumber business. About 25,000,000 feet was used on the harbor, besides amount shipped as above. No record kept of amount shipped by rail.

Canneries did not run last year. A large amount of salmon was shipped in bulk, of which no record was kept.

IMPORTS.

Articles.	Quantity.	Value.	Remarks.
	Tons.		
General merchandise, machinery, pig iron, hay and feed, and live stock.	41,000	$2,343,150	No record of separate articles.

The above shipments were made by steam and sailing vessels; no record available of freight receipts by rail.

Farmers on Gray Harbor are beginning to supply the home market with produce, thus reducing the incoming shipments.

Vessels built during the year.

Name.	Registered tonnage.	Draft, loaded.
		Feet.
Steamer City of Aberdeen	244.84	.....
Steamer Clan McDonald	230.48	.....
Four-masted barkentine Chehalis	686.00	18
Four-masted barkentine Gleaner	392.68	16

CHEHALIS RIVER TRAFFIC.

Chehalis River is in the collection district of Oregon. The nearest light-house is on Toke Point at the entrance to Shoalwater Bay, 16 miles south of Gray Harbor, into which the river empties. Aberdeen is the subport of entry.

Number of river steamers plying upon Chehalis River to Gray Harbor, 9.

Estimated amount of freight carried by same, 20 tons per day besides lumber, etc., moved on scows and lighters. (Cattle and other live stock are also delivered in this way.)

Steamer *Tillie* makes regular trips to Oychut and Damons Point.

Steamer *Aberdeen* makes regular trips from South Aberdeen to Hoquiam.

Steamer *Typhoon* makes regular trips from South Aberdeen to Petersons Point.

Steamer *Clan McDonald* makes regular trips from Montesano to Petersons Point.

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Steamers *Progress, Jessie,* and *Chicago* make regular trips from Aberdeen to South Aberdeen.

The naphtha launch *Sun Beam* makes daily trips with the mail up the Wishka River, 14 miles. These boats all touch at way landings.

One new shingle mill has recently been built and is now in operation, and six more are in course of construction at different points on the river and harbor. Two box factories also established, one in operation, and the other about finished. At least two more sawmills will be built during the coming year. The Northern Pacific Railroad is now in operation to South Aberdeen, and lumber and shingles are being handled over this line.

Acres under cultivation have increased about 100 per cent during the year, and a corresponding increase is anticipated during 1892.

T T II.

IMPROVEMENT OF SKAGIT, STILLAGUAMISH, NOOKSACK, SNOHOMISH, AND SNOQUALMIE RIVERS, WASHINGTON.

Description of original condition.—The waters of these rivers all rise in the Cascade Range and flow to the west into Puget Sound between the forty-eighth and forty-ninth parallels of latitude.

In their original condition they carried water enough for the purpose of steamer navigation, but were obstructed by snags, fallen trees, and log jams. They were the great highways of the country, traveling on land being almost impossible on account of the heavy timber, dense underbrush, and fallen logs.

The Snoqualmie is a branch of the Snohomish.

The aggregate length of all is estimated to be about 250 miles.

Plan of improvement.—The plan of improvement contemplates the removal of snags, logs, trees, and other obstructions to navigation. For this purpose a snag boat with an outfit of tools and appliances has been provided. This boat passes from one river to another, doing service in each as far as the necessities of its commerce require and as the amount of the funds appropriated will admit.

With the funds that have been appropriated this snag boat and outfit have been provided, and a large number of snags, jams, overhanging trees, and other obstructions to their navigation removed. These, with the trees that from time to time fall into the rivers, will furnish constant employment for the snag boat for an indefinite period.

APPROPRIATIONS.

Act of—	
June 14, 1880	$2,500
August 2, 1882	20,000
July 5, 1884	10,000
August 5, 1886	10,000
August 11, 1888	15,000
September 19, 1890	12,000
Total	69,500

The amount expended to June 30, 1891, was $62,118.51.

Results obtained to June 30, 1891.—In this class of work no permanent results are aimed at or obtained. The constantly recurring snags and fallen trees, etc., are required to be constantly removed. The rivers have been kept open for navigation and many of the perils of navigation have been removed.

The amount expended during fiscal year ending June 30, 1892, was $5,377.07.

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Results obtained to June 30, 1892.—The results obtained were to greatly benefit navigation.

Report of operations.—In July, 1891, the snag boat was put in commission and after receiving her supplies at Seattle proceeded to the Snohomish, where snagging operations were carried on until September 11.

On September 11 the boat started for the Skagit, stopping on the way at the Stillaguamish to do some necessary work.

Work was continued on the Skagit from September 15 to September 29, at which date the boat started for the Nooksack River.

Work was continued on the Nooksack until November 6.

On this date the boat started for its winter quarters, stopping, however, in the Skagit and Stillaguamish to do some needed work.

The boat was laid up in Deadwater Slough of the Snohomish River November 15, 1891.

During the working season 1,175 snags were removed and 144 leaning trees cut from the banks to prevent them from falling into the stream.

Capt. Jefferson's report, which is herewith, gives details of the work done.

Capt. Jefferson has been employed during the time the snag boat has been laid up on duties connected with the building of bridges and obstructions in the navigable waters of western Washington. In this connection his services have been of great value.

His report giving a summary of the work done is herewith.

Recommendations and remarks.—The minor waterways of western Washington, consisting of the tributaries of Puget Sound, are of great importance in the development and prosperity of the country, and they should be kept as free from snags and other obstructions as possible.

The snag boat is on hand and can be kept employed almost constantly to good advantage.

An appropriation of $30,000 is recommended for this work.

Future operations.—The snag boat will be put to work and kept at work to as great an extent as possible with the funds available.

Money statement.

July 1, 1891, balance unexpended	$7,381.49
June 30, 1892, amount expended during fiscal year	5,377.07
July 1, 1892, balance unexpended	2,004.42
July 1, 1892, outstanding liabilities	200.00
July 1, 1892, balance available	1,804.42
Amount appropriated by act approved July 13, 1892*	15,000.00
Amount available for fiscal year ending June 30, 1893	16,804.42
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	30,000.00

*This appropriation was made under the title "Improving Puget Sound and its tributary waters, Washington."

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REPORTS OF MR. E. H. JEFFERSON.

(1)

SEATTLE, WASH., *June 8, 1892.*

SIR: As master of the United States snag boat *Skagit*, I have the honor to submit the following annual report of operations for the seasons of 1891 and 1892, at improvement of Skagit and other rivers, Washington:

On July 21, 1891, instructions being received, preparations were commenced for placing the boat in commission again, she having been laid up for several months.

A crew was engaged, the boat got in readiness, taken to Seattle to receive supplies, and on the 31st of same month commenced snagging operations at Clarks Bend in the Snohomish River, continuing work in that vicinity till August 8. On that date started for a trip of examination to the different rivers named in the appropriation bill, with Col. G. H. Mendell and yourself on board. The Stillaguamish, Skagit, and Nooksack rivers were visited and examined as far up as was deemed practicable.

Returned again to the Snohomish River on the evening of the 10th, and resumed snagging operations the following day, continuing on that river working between its mouth and a point about 5 miles above Snohomish City until September 11, during which period Clarks Bend, a very bad place and dreaded by steamboat men, was thoroughly cleaned of obstructions, and the remains of an old abandoned log boom, a serious obstruction at low tide, was also renoved.

September 11 departure was taken for the Skagit River, stopping at the Stillaguamish on the way, doing some necessary work there.

On the 15th of the same month commenced work on the Skagit, continuing there till the 28th, working between its mouth and the "Cut Off," a point about 35 miles up.

On the 29th of September departed for the Nooksack River, commencing work on that stream on October 1, continuing between its mouth and Lynden, the practical head of navigation, until November 6, removing many dangerous snags and pretty thoroughly clearing the channel to the point named.

November 7 passed out of the Nooksack River, bound for the Skagit. We were storm bound at Fairhaven two days, and arrived at Mt. Vernon on the Skagit on the 10th, finding the river banks full and too high for work.

November 12 worked near Skagit City, and in the evening ran over to the Stillaguamish.

November 13 worked in the south channel of Stillaguamish till high tide, then left for the Snohomish River to lay the boat up for the winter, as per orders previously received.

Laid the boat in Deadwater Slough near the town of Everett; took apart machinery, pipes, etc., properly cared for same and stowed away tools, gear, etc., finishing, and discharging the crew on the 15th of November, 1891.

Following is a summary of the snag boat's operations for the period stated:

Snags and drift removed:		
Snohomish River		528
Stillaguamish River		43
Skagit River		176
Nooksack River		428
Total		1,175
Largest diameter	feet	8
Smallest diameter	inches	4
Total length	feet	25,220
Leaning trees chopped from the banks:		
Snohomish River		78
Nooksack River		66
Total		144
Largest diameter	feet	4
Smallest diameter	inches	3½
Total length	feet	5,760

In addition to the above, the boat machinery, tools, gear, etc., were kept in repair.

The snag boat has undoubtedly been of great service to the navigable interests of these rivers, and the comments of the steamboat men who know what has been done are generally of a favorable character. The only regrets seem to be that the appropriations are inefficient to keep the snag boat in commission the greater part of the time.

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There will always be some complaint by people living on these streams from the fact that when the water is low steamers can not reach them, and of course the Government and its representatives are held responsible, or, rather, blamed for it, notwithstanding that at some of the shoal places a canoe can scarcely navigate.

The fact is our snag boat is rather too large for the upper waters of these streams; she can not get up to these shoal places when the water is low, and when she can get up, the water is too high and swift to do any work. For these swift shoal places she should be equipped with additional appliances, such as a spud, or grouser, placed so that it could be dropped on the river bed through the deck and bottom of the boat, so as to hold her on these riffles, thus affording a chance to do work. A good hydraulic pump should also form part of her equipment, so the sand and gravel could be washed away from obstructions and thus permit them to be removed. A good heavy drag of some kind would also be useful.

Two regular steamers are kept employed on the Skagit River route from Seattle, and one locally from Mt. Vernon to "up-river" points when stage of water will permit. Occasional trips are made by other steamers.

The Nooksack River has two small steamers running from Bellingham Bay points when business demands.

On the Snohomish there are five regular steamers at present running from Tacoma and Seattle and six more that are engaged locally on it and its tributaries, the Snoqualmie and Skykomish. Tugs with lighters containing building material and machinery and steam barges with same made frequent trips to the Snohomish. In fact, there is more steamboat business done at the present time on the Snohomish and tributaries than on all the other rivers combined. Business on this stream has doubled and trebled during the year, on account of the establishment of the new town of Everett and the manufacturing enterprises connected therewith, as well as the boom given business by the construction of the Great Northern Railroad and the Everett and Monte Cristo Railroad of 61 miles to the mines of the Cascade Mountains.

Steamboat business has fallen off considerably on the other rivers, owing to the dull times and railroad competition to many river points.

Accurate commercial statistics are almost impossible to obtain for these rivers. The following, for merchandise in tons and passengers in numbers, are estimated to be nearly correct as representing the steamboat business on these rivers at the present time, and which has prevailed for the greater portion of the year. The figures given are monthly statements:

Route.	Freight.	Passengers.
	Tons.	*No.*
Skagit River	1,200	1,000
Nooksack River	300	100
Snohomish and tributaries	3,000	2,500

Very respectfully, your obedient servant,

E. H. JEFFERSON.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

(2.)

SEATTLE, WASH., *June 8, 1892.*

SIR: I have the honor to submit the following report of my operations in connection with the examination and inspection of the bridges and obstructions pertaining to the various rivers emptying into Puget Sound, Gray Harbor, and Willapa Bay, Washington, for the fiscal year about ending.

During the period stated the following bridges and structures have been examined, inspected, and reported upon:

A bridge over the Snohomish River at the city of Snohomish, built by the city and completed.

Bridges of the Snohomish, Skykomish and Spokane Railroad Company (now called the Everett and Monte Cristo Railroad) over the Snohomish River and Ebey Slough, completed.

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The Seattle and Northern Railroad Bridge over the Swinomish Slough, completed.

The Valley Street Railroad Company's bridge over the Duwamish River, completed.

The Northern Pacific Railroad Company's bridges over the Chehalis and Johns rivers, completed.

The county bridge over the Snoqualmie River, not yet commenced.

The county bridge over the Skagit River at Mount Vernon, not yet commenced.

The county bridges over the Willapa and Bear rivers, in course of construction.

The Everett Land and River Improvement Company's bridges over the Snohomish River and Ebey Slough, in course of construction.

The Snohomish and Port Gardner Electric Motor Company's bridges over the Snohomish River and Ebey Slough, in course of construction; and the Skagit County bridge over Swinomish Slough, in course of construction.

Several trips have been made to the sites of some of these bridges, first, to examine and to determine if they were properly located so as not to interfere with the interests of navigation, then to see that they were being built and completed according to the plans submitted and approved.

During the same period the following obstructions to navigation complained of have been examined and reported upon:

The obstruction of the entrance to the Nooksack River by the Bellingham Bay Boom Company.

Obstruction of the Wishka River by the log boom of one Frank Miller.

Obstruction to the entrance to the Stillaguamish River by the Chinook Boom Company.

Obstruction to Ebey Slough by the boom of Stimpson Mill Company.

The obstruction of Steamboat Slough (Snohomish River) by certain parties felling large trees in the stream while pursuing the work of diking land.

The obstruction of free and safe navigation of the Snohomish River by the sheer booms of Pearl & Tompkins.

The obstructive character of the bridges of the Seattle and Montana Railroad over the Snohomish River and Steamboat Slough and a subsequent felling of trees into Steamboat Slough by the parties engaged in building a dike around Ebey Island.

At most of these places measurements and soundings were taken.

Very respectfully, your obedient servant,

E. H. JEFFERSON.

Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

T T 12.

PRELIMINARY EXAMINATION AND SURVEY OF OLYMPIA HARBOR, WASHINGTON, FROM DEEP WATER IN BUDDS INLET TO FOURTH STREET BRIDGE, IN THE CITY OF OLYMPIA, AND SEPARATELY FROM SAID BRIDGE TO THE MOUTH OF THE DES CHUTES RIVER AT TUMWATER.

[Printed in House Ex. Doc. No. 32, Fifty-second Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., November 20, 1891.

SIR: I have the honor to submit herewith copy of report dated January 12, 1891, on preliminary examination of "Olympia Harbor, Washington, from deep water in Budds Inlet to Fourth Street Bridge in the city of Olympia, and separately from said bridge to the mouth of the Des Chutes River, at Tumwater," and copy of report, with map,* dated September 19, 1891, on survey of Olympia Harbor, Washington, from deep water in Budds Inlet to Fourth Street Bridge, Olympia, made by

* Not reprinted; printed in House Ex. Doc. No. 32, Fifty-second Congress, first session.

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Capt. Thomas W. Symons, Corps of Engineers, in compliance with the provisions of river and harbor act approved September 19, 1890.

For the facts and reasons given in report of January 12, 1891, Captain Symons does not consider Des Chutes River above the Fourth street bridge, Olympia, to Tumwater, worthy of improvement. I concur in this opinion.

The proposed improvement of Olympia Harbor below the Fourth street bridge contemplates dredging a channel from deep water in Budds Inlet to the wharves near the bridge, 12 feet deep at low water and 250 feet wide, between pile and brush bulkheads built 400 feet apart, beyond which the dredged material is to be deposited; and the formation of a basin at the upper end of the cut, near the bridge, 12 feet deep at low water, with an extreme length of 1,600 feet and maximum width of 500 feet, the bulkhead to be continued around the sides and end of the basin, so as to deflect the current of the Des Chutes River, provision being made, however, to allow small boats to pass through the draw of the bridge. The cost of this work is estimated at $275,000.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

PRELIMINARY EXAMINATION OF OLYMPIA HARBOR, WASHINGTON, FROM DEEP WATER IN BUDDS INLET TO FOURTH STREET BRIDGE, IN THE CITY OF OLYMPIA, AND SEPARATELY FROM SAID BRIDGE TO THE MOUTH OF THE DES CHUTES RIVER, AT TUMWATER.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, January 12, 1891.

GENERAL: I have the honor to state that, in obedience to the instructions contained in your letter of September 20, 1890, a preliminary examination has been made of "Olympia Harbor, Washington, from deep water in Budds Inlet to Fourth street bridge, in the city of Olympia, and separately from said bridge to the mouth of the Des Chutes River at Tumwater, and to report as to the most practical and convenient channel, and the most feasible, economical, and suitable plan for improving the same for navigation by the class of vessels employed on Puget Sound, and also to cause to be made an estimate of the cost of each of such improvements."

In this connection attention is invited to the fact that in 1885 Capt. C. F. Powell, Corps of Engineers, submitted a report on Olympia Harbor with plan and estimate for its improvement, he having reported that it was worthy of improvement. Captain Powell's report is contained in Chief of Engineers' Report, 1885, page 2413.

In order to obtain the latest information in regard to the harbor and city, Mr. A. J. McMillan was dispatched to the locality and made the report which is herewith.

In my opinion Olympia Harbor from Fourth street bridge to deep water in Budds Inlet is worthy of improvement, to make it navigable for the class of vessels employed on Puget Sound.

This opinion is based upon the facts set forth in Mr. McMillan's report. These may be summarized by stating that Olympia is the capital of Washington and is a city of considerable commercial and manufacturing importance, which must naturally develop rapidly now that the

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great railroads are getting there. The harbor is rendered very inconvenient by reason of the extensive shoaling at the head of Budds Inlet. The United States Coast and Geodetic Survey chart of Olympia Harbor shows the situation very well.

In regard to that portion of the inlet from Fourth street bridge to Tumwater, I do not deem it worthy of improvement for the reason set forth in Mr. McMillan's report.

Nearly all the data necessary for the preparation of plans and estimates for the works of improvement recommended are available now in this office. Only data showing recent changes will have to be gathered. It is estimated that this and the preparation of plans, estimates, and reports will cost $250.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., January 17, 1891.

Respectfully forwarded.

For reasons herein stated, Olympia Harbor is worthy of improvement as to the portion extending from Fourth street bridge to deep water in Budds Inlet.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

REPORT OF MR. A. J. McMILLAN.

OCTOBER 29, 1890.

CAPTAIN: I have the honor of submitting the following report of a preliminary examination of Olympia Harbor at the head of Budds Inlet, Puget Sound, State of Washington, made in accordance with your instructions.

From the mouth of the Des Chutes River to 4,500 feet north of Fourth Street Bridge, in the city of Olympia, is bare mud flat or tide land at low water, with the water of the Des Chutes meandering through it, in a channel not deep enough in places to row a boat, making navigation impossible at that stage of the tide. It takes something over quarter tide for the stern-wheel steamers to reach Fourth Street Bridge. There is a wharf piled out over the tide land for over a mile, but even that distance does not reach water deep enough for the class of steamers that come to Olympia. What the people want is a channel deep enough for ocean steamers to reach the vicinity of Fourth street; and that will necessitate the dredging of about 2 miles. The material consists of fine gravel, sand, and clay, making easy dredging.

I interviewed several members of the Chamber of Commerce in regard to the item in the river and harbor bill for making a channel from Fourth Street Bridge to Tumwater, and they all stated that they did not want or expect the Government to do it, because it would cost a large amount of money, and would be of no benefit if it was done.

In regard to shipping, railways, manufactures, etc., I obtained the following information:

There are nine passenger steamers making regular trips from Olympia to points on the Sound.

The Union Pacific, Northern Pacific, and the Port Townsend Southern Railway companies are building their lines within the city limits. The Northern Pacific Company have a dredger at work at present at the foot of Seventh street, filling in

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some 7 acres for depot grounds. The Union Pacific Company are going to fill in some 15 acres for the same purpose at another part of the harbor. The Port Townsend Southern Company are driving piling for coal bunkers. The coal will come from the company's large coal fields about 25 miles south of Olympia, near the Portland-Tacoma branch of the Northern Pacific Railway.

Everything points to Olympia becoming quite a railway and shipping center in the near future.

The manufactories of this place at present consists of two sawmills, one planing mill, one wooden water-pipe factory, and one foundry and machine shop. This place has until lately been without railway or shipping facilities, and there was no inducement for capitalists to invest in any kind of business.

Although Tumwater is about 2 miles from Olympia, it is practically a part of it. Tumwater has one sawmill, one sash and door factory, and one box factory. There is being built here a flouring mill of 100 barrels capacity; also a large dam for supplying power to electric-light and street-railway plants.

Tumwater has a population of about 400 and Olympia has about 6,000. Olympia has increased in population about 300 per month since last spring.

Very respectfully, your obedient servant,

A. J. McMillan.

Capt. Thomas W. Symons,
Corps of Engineers, U. S. A.

SURVEY OF OLYMPIA HARBOR, WASHINGTON, FROM DEEP WATER IN BUDDS INLET TO FOURTH STREET BRIDGE IN THE CITY OF OLYMPIA.

United States Engineer Office,
Portland, Oregon, September 19, 1891.

General: I have the honor to submit the following report upon the "improvement of Olympia Harbor":

The river and harbor bill approved September 19, 1890, contained an item for making a preliminary examination and estimate for "Olympia Harbor, Washington, from deep water in Budds Inlet to Fourth Street Bridge in the city of Olympia, and separately from said bridge to the mouth of the Des Chutes River at Tumwater, and to report as to the most practical and convenient channel and the most feasible, economical, and suitable plan for improving the same for navigation by the class of vessels employed on Puget Sound, and also to cause to be made an estimate of the cost of each of such improvements."

Being charged with the duty of making this examination and report I submitted a report thereon, under date of January 12, 1891.

Under date of January 23, 1891, I was charged with the survey of "Olympia Harbor, Washington, from deep water in Budds Inlet to Fourth Street Bridge, in the city of Olympia."

In 1885 a survey was made of Olympia Harbor, and plans and estimates for its improvement made by Capt. C. F. Powell, Corps of Engineers. The map made at this time was used as the basis of the present plans and estimates, the only changes being the necessary corrections to bring it up to date. The tracing submitted* herewith shows the plan recommended for the improvement of the harbor.

Captain Powell's report, page 2413, Report of Chief of Engineers for 1885, the preliminary report already submitted by myself, Mr. DeCourcy's report, which is herewith, and the map submitted, are, it is believed, sufficiently descriptive of the locality to need little further in this line. The situation, however, may be summarized as follows:

Olympia, the capital of the State of Washington, is situated near the head of Budds Inlet, which at this point is about 2,000 feet wide. At Olympia, and for about 4,000 feet below, the inlet is a tide flat, mostly bare at low water. The general range of the tides is about 18 to 20 feet. At high water boats can go up to Fourth Street Bridge, but at

* Not reprinted; printed in House Ex. Doc. No. 32, Fifty-second Congress, first session.

low water they are compelled to land passengers and freight at the end of the long wharf about 1 mile from the city.

The plan proposed for the improvement of the harbor consists in making a channel from deep water, so that "the class of vessels employed on Puget Sound" can, at nearly all times, reach the wharves at Fourth Street Bridge.

I have interpreted the phrase "the class of vessels employed on Puget Sound" to mean those vessels which ply from port to port on the sound, in contradistinction to the deep-draft, seagoing vessels which ply to and from the sound.

The following list gives the dimensions of the principal boats of the sound:

Name.	Length.	Beam.		Net tons.	Draft.		Description.
	Feet.	*Ft.*	*in.*		*Ft.*	*in.*	
Olympian	261	40		1,083.20	9		Iron, side-wheel.
City of Seattle	254	40		912.73	13		Iron, propeller.
City of Kingston	246	33	5	866.35	12	5	Do.
Premier	200	42		602.00	9		Do.
Eastern Oregon	200	34		577.81	10		Do.
Tyee	141	26		158.77	16		Wood, propeller.
Sea Lion	107	22		92.77	10	6	Iron, propeller.
Pioneer	107	21		80.48	11		Do.
T. J. Potter	230	35		589.00	10		Wood, side-wheel.
Goliah	154	30		350.00	9	8	Do.
Eliza Anderson	134	25		197.49	7		Do.
North Pacific	166	29		345.46	9		Do.
Geo. M. Starr	148	28		336.00	8	6	Do.
Idaho	147	25		178.00	6	4	Do.
State of Washington	170	31		449.00	7		Wood, stern-wheel.
Skagit Chief	137	26		241.00	5	6	Do.
Emma Hayward	177	29		466.00	7	5	Do.
Washington	141	24		193.08	5	6	Do.
Edith	120	24		135.99	9	7	Wood, propeller.
W. K. Merwin	108	22	5	166.00	4	6	Wood, stern-wheel.
Yakima	117	22		100.00	6	6	Do.
Henry Bailey	108	25		209.00	4	6	Do.
Multnomah	143	28		278.00	5		Do.
Hassalo	160	30		350.00	6		Do.
United States snag boat Skagit	130	31		(?)		26	Do.

Twelve feet at lower low water was fixed upon as the proper depth to be given the channel, as this depth will accommodate very nearly all the vessels plying on the sound and more than accommodate any now plying to Olympia. It is fair to suppose, however, that, as Olympia grows, sound vessels of the largest class will visit it.

A width of channel of 250 feet was fixed upon, as this will permit boats to pass each other and will allow those at present calling at Olympia to turn. It is, however, deemed wise in laying out the work to provide for a width of 400 feet in the future, which will be desirable if the commerce of Olympia shall grow as anticipated by some. This width will enable vessels to lie at each side of the channel and yet leave room for others to pass in and out.

This width it is proposed to provide for by putting the bulkheads, beyond which the dredged material will be deposited, 400 feet apart. It is also now proposed to dredge out a basin at the upper or southern end of the channel, in plan as shown on the accompanying map. This basin has an extreme length of 1,600 feet and a maximum breadth of 500 feet, and is designed with a view of interfering as little as possible with existing wharves and docks.

The method of construction proposed is to build a pile and brush bulkhead on the line shown, and to pump the material from the channel and deposit it beyond the bulkhead.

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It is deemed best to keep the Des Chutes River out of this channel. as it is feared that, under favoring circumstances, it would tend to fill the channel with débris from above. This deflection will be accomplished by building the bulkhead completely around the upper end and sides of the channel. Provision for passing small boats through the draw of the Fourth street bridge can be made by limiting the height of the bulkhead at the draw to just sufficient elevation to turn the waters of the Des Chutes. This will enable anything that is likely to desire to do so to get above the bridge.

The work of constructing the 250-foot channel with basin, as shown, is estimated to cost $275,000.

ESTIMATE FOR THE IMPROVEMENT OF OLYMPIA HARBOR, WASHINGTON.

For a dredged channel 250 feet wide (bottom width) and 12 feet deep at low water, bulkheads 400 feet apart, and a basin of equal depth in plan, as shown on accompanying map:

70,775 linear feet of piles, at 15 cents driven	$10,616.25
16,705 feet, B. M., cross bracing for basin bulkhead, at $20 in place	334.10
9,400 feet, B. M., longitudinal bracing, bulkhead, at $20	188.00
3,000 cords brush, at $2.50 in place	7,500.00
1,000 tons stone ballast at $2, in place	2,000.00
1,141,575 cubic yards excavation, at 20 cents dredged	228,315.00
3,000 pounds iron spikes, at 10 cents in place	300.00
Add 10 per cent for superintendence and contingencies	24,925.33
	274,178.68
In round numbers	275,000.00

The following commercial statistics of Olympia have been furnished by the Board of Trade of the city:

Population of Olympia, census—	
1890	4,696
1889	3,238
Increase in one year	1,458
Gain (per cent)	45
Population of Thurston County, census—	
1890	9,675
1889	7,236
Increase in one year	2,439
Gain (per cent)	33.7

MANUFACTURING INTERESTS OF OLYMPIA.

West Side Mill Company (lumber): Employés, 60; capacity, 50,000 feet daily; capacity, lath, 10,000 daily; capacity, pickets, 10,000 daily; pay roll, $4,000 per month.

D. Allison & Co. (lumber): Employés, 20; capacity, 10,000 feet daily; pay roll, $1,300 per month.

George S. Allen (lumber): Employés, 30; capacity, 25,000 feet daily; capacity, lath, 10,000 daily; pay roll, $2,200 per month.

Springer & White (lumber): Employés, 50; capacity, work up 2,000,000 feet per year; capital, $50,000; pay roll, $3,200 per month.

T. Z. Slater (shingles): Employés, 20; capacity, 100,000 daily; pay roll, $1,200 per month.

Tumwater Shingle Company: Employés, 15; capacity, 70,000 shingles daily; pay roll, $1,000 per month.

Puget Sound Pipe Company (pipe factory): Capital, $50,000; capacity, six miles assorted pipes per month; employés, 50; pay roll, $4,000 per month.

Olympia Foundry and Machinery Company: Employés, 15; capacity of foundry, 4 tons daily; pay roll, $1,000 per month.

Sternberg's Furniture Factory: Employés, 15; pay roll, $1,000 per month.

Miller & Springer (cigar factory): Employés, 7; pay roll, $450 per month.

Electric plant: Electric Light and Power Company. Flour mill: capacity, daily,

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125 barrels; 50 tons chopped feed; complete corn-meal plant; employés, 10; pay roll, $600 per month. Lighting plant: Capacity, 3 arc dynamos, operating 130 arc lights; 2 railroad generators, 150 horse power each; 2 incandescent lights; 1 motor, 100 horse power; employés, 15; pay roll, $900 per month. They have 28 miles arc wire and 15 miles of incandescent wire strung.

Olympia water works: Employés, 15; pay roll, $1,000 per month; capacity, 2,000,000 gallons daily; pressure, 45 pounds, both fire and domestic; reservoir holds 2,700,000 gallons.

NAVIGATION.

There are ten companies operating boats on the sound at Olympia, which are as follows, giving names of boats and their tonnage per annum for 1890:

Companies.	Names of boats.	Tonnage.
Union Pacific Railway Co	Steamer Potter Steamer Hassallo Steamer Emma Hayward Steamer Olympian Steamer North Pacific	7,000
Columbia River and Puget Sound Navigation Co	Bailey Gatzert Fleetwood	1,200
Brown's Wharf and Navigation Co	Clara Brown	6,000
S. Willey Steamship Co	Multnomah Willey	4,100
Puget Sound and Alaska Steamship Co	Washington W. K. Merwin	2,500
Pacific Navigation Co	State of Washington Cascade	1,100
Port Blakely Mill Co	Steamer Nellie	2,000
St. Paul and Tacoma Lumber Co	Zephyr Messenger	500
Walter Axtell	Jessie	500
H. M. Perin, agent	Steamer The Doctor	1,000
Total tonnage of all boats for 1890		25,900

The increase of tonnage on boats for year 1890 over 1889 is 30 per cent; at this rate the tonnage for 1891 will be 33,670 tons. This is a low estimate, as the Union Pacific Railroad Company has just closed one contract for receiving the material for a new court-house which amounts to over 6,000 tons.

The tonnage for the year 1890 on the Port Townsend Railroad Company was 15,000 tons.

The Northern Pacific Railroad has just completed its line to Olympia, and the Union Pacific will be completed in a few months, so a conservative estimate of the increase in railroad tonnage would be at least 200 per cent, or 45,000 tons.

Total valuation of all property, as equalized by the board of equalization.

	1889.	1890.
City of Olympia	$1,144,621	$3,296,388
County (outside of Olympia)	1,492,065	3,260,477
Thurston County	2,636,686	6,556,865
Increase in valuation in one year		3,920,179
Per cent of gain in one year		148.6

FINAL ASSESSMENT FIGURES.

The final figures for the city assessment, as equalized by the Board, show the real estate assessment to be $5,597,455, which was reduced

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$40,617, leaving a total of $5,556,838. The personal assessment was $759,607, and was reduced $3,225, making a total for both real and personal of $6,319,670, on which a 6-mill tax is levied.

There is submitted herewith the report of Mr. Bolton W. DeCourcy, who made the reëxamination and survey of Olympia Harbor.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., September 30, 1891.

Respectfully forwarded to the Chief of Engineers, Washington, D. C., recommended.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

REPORT OF MR. BOLTON W. DECOURCY.

PORTLAND, OREGON, *March 17, 1891.*

CAPTAIN: I have the honor to report that, in obedience to your order given February 16, 1891, I proceeded to Olympia, Wash., and made the survey as directed.

I held consultation with most of the principal citizens to ascertain their wishes and ideas of what was necessary for the improvement of the harbor; also with the city officials, the names of a few of whom I will mention:

The mayor of Olympia, Mr. Ellis, Mr. Sickles, and others of the city council; Governor Laughton, General McKenny, Hon. Thos. H. Cavanaugh, surveyor-general; Captain McMicken, Mr. Phillips, president of the First National Bank; Mr. Shannon, vice-president of the same bank; Mr. Chaplin, Mr. Gowey, Mr. Robinson, proprietor of the Olympia Daily Tribune; and Mr. Phelps, manager of the Port Townsend Southern Railroad. These gentlemen are among the heaviest tax-payers and largest property owners in Olympia.

I had conversations also with Messrs. Pease, Willey, Parker, Hennessey, and Hatch. These gentlemen command the largest steamers running between Olympia and Sound ports.

All these persons were unanimous in recommending and requesting the consideration of a channel commencing at the Fourth Street Bridge, where the draw is situated, and between the wharves owned by Mayor Horr and Mr. Ellis, and running direct in a northerly course to deep water.

The steamer masters ask that the channel be made quite straight in alignment, claiming that this would confer one of the most material benefits to be derived from an improved channel, as the fogs are frequent about Olympia and it would be difficult for them to keep their steamers from grounding should it deviate from a straight line.

The citizens advocate a depth of 16 feet at lower low water, on the expectation of, in that case, having the ocean steamships plying between San Francisco and Portland and the ports of Puget Sound come direct to Olympia to discharge any portion of their cargoes destined for that city, instead of transferring at Seattle or Tacoma, as at present.

The steamer masters mentioned above, on the other hand, say that 12 feet depth at lower low water is ample for all purposes.

I was informed that the daily arrival of steamers at the present time is nine, of which four are large ones plying from Seattle; the remainder are small, running to insignificant places on the different islands and inlets of the sound.

The different masters of these large boats do not deem a basin necessary for their convenience in turning their craft. They say they prefer backing out, taking advantage of the deep water in a northwest direction from the place where the sight

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post is situated, then steaming ahead into the channel and turning north. Proceeding thus, they say, saves time over making a complete turn in a basin. However, should the channel be improved to 12 feet depth it will be necessary to also excavate some in this channel.

The Bowers dredge had completed its work when I arrived, and had left for Tacoma. I ascertained, however, that the dredge had excavated and deposited inside the revetment or bulkhead for the Northern Pacific Railroad Company 250,000 cubic yards.

The dredge was brought there from Tacoma about the 10th of November. The borrow-pit is parallel with the bulkheads and distant therefrom 500 feet. It is 400 feet wide and 17 feet deep at low water. At one place, in consequence of neglecting to cut off some springs, the pile bulkhead gave way. I took advantage of this place to endeavor to obtain the natural slope of the material, which is composed of sand, silt, and small gravel. As nearly as it was possible to judge, it showed two horizontal to one perpendicular.

As to width of channel, the masters of the steamers recommend, and the citizens request the consideration of a bottom width of 250 feet. The space left between the piling of the Horr and Ellis wharves is about 95 feet; otherwise there are no improvements encroaching on the space called for by such a channel.

The Des Chutes River has not sufficient water to be useful for scows; at lower low water its channel through the mud flats is not over 20 feet wide and 2 to 3 feet deep. It will be necessary to deflect it and prevent its discharge into any artificial channel made. The river has a small channel at the west end of the Fourth Street Bridge, which will become the main channel by preventing the water from getting into that dredged. This can be done by a short bulkhead above the Fourth Street Bridge near where the channel divides.

The steam vessels plying to Olympia, with their depth of draft, are as follows:

The *T. J. Potter*, 7 feet (according to her mate and first officer) or 10 feet (as given by Mr Jefferson); the *Bailey Gatzert*, 7 feet; the *Washington*, 5½ feet; the *Multnomah*, 5 feet; the *Willie*, 4 feet; the *Nellie*, 4 feet; the *Clara Brown*, 6 feet; the *Jessie*, 4 feet; the *Colby*, 4 feet; the *Emma Hayward*, 7½ feet; the *Hassallo*, 6 feet. The first nine of the above are regular arrivals; the last two occasional. There are tugs also that put in, and sometimes a schooner. These draw from 8 to 9 feet.

The citizens of Olympia with whom I conferred all stated that the long wharf in the event of harbor improvement would be abandoned. In that case the piling might be used for revetment purposes as far as the wharf reaches, saving a good deal of new piling.

The total length of excavation required to reach 12 feet depth at lower low water will be 8,400 feet.

The steamer *Potter* is 230 feet in length, beam 35 feet, as stated by Mr. Jefferson. She is the largest steamer at present calling at Olympia.

The masters of the several steamers with whom I conversed said that when the wind was blowing hard, in order to turn they hold on to the wharf with their stern lines and swing the head round. This requires for the *Potter* about the width requested for the bottom, *i. e.*, 250 feet. A high wind would blow them onto the shallows if they endeavored to turn by backing out.

Piling can be procured at 5½ cents per linear foot.

The narrow gauge from Tenino, since it came into the hands of the Oregon Improvement Company, has been made standard gauge and extended to the coal bunkers at Brittlers Cove, and its depot established at the crossings of Fourth Street Bridge.

The Tacoma, Olympia, and Gray's Harbor Railroad, being built by the Northern Pacific, is in an advanced state, and it is expected will be finished in sixty days. The Portland and Puget Sound Railway Company has a good deal of grading done, but has suspended work for the present.

The above is the entire improvement, as far as roads in contemplation are concerned.

I have made a map and estimate, with tracings of the result of the survey.

Respectfully submitted.

BOLTON W. DECOURCY.

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[Printed in House Ex. Doc. No. 35, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF TILLAMOOK BAY AND BAR, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 2, 1890.

GENERAL: I have the honor to state that in accordance with the direction in your letter of September 20, 1890, a preliminary examination has been made of Tillamook Bay and Bar, Oregon, and the following report thereon is submitted:

Tillamook Bay and Bar were first examined in 1886 by Lieut. Edward Burr, under direction of Capt. C. F. Powell. In 1887 a survey was made of the interior waters under direction of Captain Powell, who in 1888 submitted a project and estimate for work to be done.

The river and harbor act of August 11, 1888, appropriated $5,200 for Tillamook Bay and Bar, and this money was expended in making a survey of the bar entrance and building a dike and revetment work, for the improvement of Dry Stocking Bar, in Hoquarton Slough.

Lieutenant Burr in 1886 and Captain Powell in 1887 and 1888 recommended that all works of improvement be confined to the inner waters, reporting that "the entrance to the bay requires no attention."

In order to obtain the most recent data with regard to the development on the bay, Mr. A. J. McMillan, assistant engineer, was dispatched to Tillamook the first part of November, 1890, to make the preliminary examination required by your orders. Mr. McMillan's report is appended hereto.

After a full consideration of all available information in regard to Tillamook Bay and Bar, I am of the opinion that the present demands of commerce do not require any work looking to the improvement of the entrance to the bay. All accounts agree that this is one of the best small bar harbors on the coast. The bar channel is straight, shifts very little and has an available depth of 10 feet and more at low water.

Tillamook City is the most important place on the bay, and seems to be situated in the best place for a local distributing point. It is desirable that the boats which regularly trade with the bay should be able to ascend to this place, and to do this it will be necessary to make improvements at Junction and Dry Stocking bars.

I am of the opinion that Tillamook Bay is worthy of improvement to the extent of improving the waters from the entrance to Tillamook City, so that vessels which can safely cross the bar can ascend thereto.

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To make a proper survey and prepare plans and estimates for the work will cost, it is estimated, about $400.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

WASHINGTON, D. C., *December 12, 1890.*

Respectfully forwarded to the Chief of Engineers.

For reasons herein stated Tillamook Bay is worthy of improvement to the extent herein recommended.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

REPORT OF MR. A. J. MCMILLAN, ASSISTANT ENGINEER.

PORTLAND, OREGON, *November 11, 1890.*

CAPTAIN: I have the honor of submitting the following report of a preliminary examination of Tillamook Bay, made in accordance with your instructions.

The entrance to Tillamook Bay is situated about 50 miles south of the mouth of the Columbia River. The entrance is straight and has a depth of about 10 feet of water on the bar at low water. It is one of the best small bar harbors on the coast, it not being subject to shifting to the north or south like many others. Steam schooners are loaded to 12 feet draft with lumber at the Hobsonville Mill, and pass safely over it. The bay has a length of over 5 miles, and a breadth of over 3. It is very shoal, being at extreme low water an immense mud flat with a few crooked channels through it. Any craft that can cross the bar has water enough to reach Hobsonville and Bay City, but not enough to reach the head of the bay on account of shoals. The worst of those shoals is the one known as Junction Bar, and is situated a short distance below where the waters of the Kilchis and Wilson rivers meet the waters of the Tillamook and Trask rivers at low water. This shoal has been formed by the sediment brought down by those streams. It is about 1,000 feet long, and has only about 1 foot of water on it at extreme low water. I think that for the improvement of this place, it would be necessary to run a low stone dike from the south side of the bay to concentrate the water on this place and keep it scoured out. The next serious obstruction to navigation in going up Hoquarton Slough to the town Tillamook, is Dry Stocking Bar, which is situated at the junction of the Tillamook River and Hoquarton Slough. This bar has at present only a few inches of water on it at extreme low water. The dike that was carried away by the freshets of last winter should be replaced as soon as possible. If those two places were improved, the schooners that now go up to the town of Tillamook, would have no difficulty in reaching there. They draw 7 and 8 feet of water and have to cross those shoals at high water.

The town of Tillamook, the principal one on the bay, is situated at the head of navigation on Hoquarton Slough, and is about 3 miles above Dry Stocking Bar. While its location is a good one in regard to the adjacent agricultural lands, it is a bad one in regard to navigation. The slough at the town is less than 100 feet wide, but it widens out toward the bar by the addition of the Daugherty, which is a part of the Wilson River that comes into it about 1 mile below town, and also by the addition of the Trask River, which enters it about 1½ miles farther down. The town has a population of about 300. There is a sawmill here of 15,000 feet capacity, which cuts mostly for local demand but occasionally ships some spruce lumber to Portland.

Bay City is situated at the place designated as Sandstone Point on the Coast Survey charts. It has a sawmill of 6,000 feet capacity, and cuts for local demand. The town has a population of about 50 persons.

Hobsonville is situated at Memaluct Point. There is a sawmill here of 50,000 feet capacity, which cuts spruce for the San Francisco market. There is also a cannery at this place, but it did not run this season.

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Garibaldi is situated at Bailey Point near the entrance. There is a cannery at this place that put up about 20,000 cases of salmon this season.

The exports of the bay for this year are as follows:

	Value.
Lumber, 12,000,000 feet	$180,000
Butter, 40 tons	16,000
Apples, 3,500 boxes	1,750
Potatoes, 4,000 bushels	2,000
Hides, 600	1,200
Sheepskins, 300	225
Stock, 400 head	8,000
Total	209,175

The vessels at present entering the bay are the steam schooners *South Coast*, *Augusta*, *Truckee*, and *Louis Olsen*. The *South Coast* and *Truckee* load at Hobsonville with lumber for San Francisco. The *Augusta* and *Louis Olsen* are coasting schooners and go up to Tillamook.

After a careful consideration I have come to the conclusion that the entrance to this bay is in good enough condition to suit all the present demands of commerce; but I consider that the Government should replace the dike at Dry Stocking Bar and do something toward the improvement of Junction Bar.

The present routes of travel to reach this bay are by daily stage from North Yamhill, by triweekly stage from Sheridan, by trail from Astoria, and by coasting schooner from Astoria.

There is being built a wagon road from Forest Grove down Wilson River to Tillamook. It will be finished by the end of next June. It will be a better road than the one from North Yamhill and have 1,400 feet less elevation on the summit of the Coast Range.

Very respectfully, your obedient servant,

A. J. McMillan.

Capt. Thos. W. Symons,
Corps of Engineers, U. S. A.

SURVEY OF TILLAMOOK BAY AND BAR, OREGON.

United States Engineer Office,
Portland, Oregon, October 19, 1891.

General: I have the honor to submit the following report upon a survey of Tillamook Bay and Bar.

The last river and harbor bill contained an item providing for the examination and survey, if found necessary, of "Tillamook Bay and Bar."

Being charged with making the preliminary examination, I submitted my report thereon under date of December 2, 1890.

Under date of December 13, 1890, I was directed to make the necessary survey.

Mr. William H. Wood was engaged to make the survey of the inner harbor, and his report is herewith.

Tillamook Bay is situated about 50 miles south of the entrance to the Columbia River, and at high tide is about 7 miles long and 2½ miles wide; at low tide it is a great sand and mud flat cut by three channels, the North, Middle, and South channels. These channels are shown on the accompanying map,* which embraces all of the bay within about three-fourths of a mile from the harbor throat.

The South Channel is unimportant, being shoal and not used for purposes of navigation.

The Middle Channel is the through channel by which access is had to the head of the bay and to Tillamook City, the principal town of the locality, which is situated on Hoquarton Slough.

The North Channel runs along the north shore of the bay from the entrance to Shell Point, about a mile above Bay City, where it terminates.

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*Not reprinted; printed in House Ex. Doc. No. 35, Fifty-second Congress, first session.

The difficulties met with in the navigation of the bay are three in number and are as follows:

First. Boats using the North Channel can not proceed up the bay except by returning down the North Channel nearly to the entrance of the bay, and then turning and going up the Middle Channel. It is proposed to obviate this difficulty by making a connection between the Middle and North channels so that boats can go to points along the north shore and then keep right on up to the head of the bay.

Second. The second difficulty is met with at Junction Bar, a shoal bar in the Middle Channel just below where the South Channel diverges from the main or middle channel. It is reasonable to believe that this bar is due to the interference of currents, and particularly to the weakening of the ebb current in the Middle Channel due to the branching off of the South Channel.

The remedy proposed for this difficulty is to partially shut off the water and stop its running into the South Channel and to confine more effectually the currents of the Middle Channel at the bar.

Third. The third difficulty consists in a shoal at a point known as Dry Stocking Bar, at the junction of Hoquarton Slough with the Tillamook River.

This is due to the widening of Hoquarton Slough and the backwater from Tillamook River.

A marshy island divides Hoquarton Slough into two channels, and the obvious remedy for the difficulty is to close up one of these channels by a dike, compelling the channel into the other and thus causing a deeper scour to take place.

A dike was constructed at this point some years ago, but was carried away by the winter freshets.

In order to make the connection between the North and Middle channels it will be necessary to dredge a channel across the intervening sand flat; and in order to maintain this channel it will be necessary to close up the Middle Channel so as to direct the ebbing and flooding waters through the dredged channel. This it is proposed to do by a dike which should be extended across the sands separating the North and Middle channels, and for some distance upon the sands bordering the Middle Channel on the south, in order to prevent the Middle Channel from cutting in around the deflecting dike.

It is proposed to make the dredged channel 200 feet wide on the bottom and 6 feet deep at low water. This will require the dredging of 65,000 cubic yards of material. The required deflecting dike will be 2,000 feet long, and can only be put in entirely across the channel after the opening of the new channel.

This dike can be built of piles, brush, and stone, at an average cost of $12 per foot. It is proposed to leave this dike 3 feet below high-water mark.

For the removal of Junction Bar a dike 5,000 feet long will be required. This will be built of piles, brush, and stone, and is estimated to cost $5 per foot.

For the removal of Dry Stocking Bar a dike will be required 950 feet in length; the dike to be built of piles, brush, and stone, at an estimated cost of $10 per foot.

The following is the estimated cost of the work proposed:

ESTIMATE.

Connection between North and Middle channels:	
Dredging 65,000 cubic yards, at 50 cents	$32,500
2,000 feet dike, at $12	24,000

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Removal of Junction Bar:	
5,000 feet dike, at $5	$25,000
Removal of Dry Stocking Bar:	
950 feet dike, at $10	9,500
	91,000
Contingencies, engineering, etc.	9,000
Total	100,000

COMMERCIAL STATISTICS.

There is given herewith the report of Mr. W. H. Wood, of date of June 16, upon the commercial statistics of Tillamook Bay.

This, together with my preliminary report and the report of Mr. A. J. McMillan accompanying it, furnish all the information available in regard to the commerce of Tillamook Bay.

TILLAMOOK CITY, *June 16, 1891.*

DEAR SIR: I have the honor to submit the following report of the commercial statistics of Tillamook Bay for the year ending June 30, 1891, as per your instructions of June 2, 1891, as follows:

Following are the separate amounts, in tons, of the exports and imports of the entire bay; the same will be found in the tabulated statement attached:

EXPORTS.

	Tons.
11,600,000 feet B. M. lumber, at 4 pounds per foot	23,200
21,000 cases canned salmon, at 72 pounds per case	756
130 barrels salt salmon, at 400 pounds per barrel	28
Butter	13
Wool	11
Hides	3
3,000 boxes apples, at 50 pounds per box	75
100 cases eggs, at 50 pounds per case	2½
Hay	50
General merchandise	50

IMPORTS.

General merchandise	3,346
Agricultural implements	90
Machinery	110
Flour	115
Feed	225
Shingles	180
Brick	40

Making a total of 24,188½ tons exported and 4,106 imported during the year.

Besides this there were exported 1,200 head of cattle which were driven out to Astoria.

VESSELS.

The number of vessels of all descriptions crossing the bar during the year was 60 in and 60 out. Their names, registered tonnage, number of trips each, are as follows:

Steam schooner.	Tonnage.	Draft.		Trips.
		Ft.	*In.*	
Truckee	350	13	6	9
Scotia	200	11	4	14
Laguna	200	11	6	10
Augusta	87	7	9	17
W. H. Harrison	70	6	9	1
Louis Olsen	80	7	6	5
Elmore	30	8	6	4

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The two vessels *Truckee* and *Scotia* ply between Hobsonville and San Francisco, carrying both freight and passengers. They load out with lumber from the Truckee Lumber Company's mill at Hobsonville for San Francisco. The *Laguna* plies between Hobsonville and San Francisco, loading out with lumber, but carries no passengers. All three of the above vessels are operated solely by the Truckee Lumber Company.

The steam schooner *Augusta* carries both freight and passengers, making irregular trips between Tillamook City and all points on Tillamook Bay and Astoria and Portland. The steam schooner *W. H. Harrison* made one trip from Portland with general merchandise for Bay City. The steam schooner *Louis Olsen*, owned by Mr. Olsen, of Tillamook City, made six trips from Portland to Tillamook City, bringing merchandise. She is now off the bay. The steam schooner *Elmore* made four trips from Astoria, bringing supplies to Mr. Elmore's cannery at Garibaldi.

There are no regular vessels plying to Tillamook City, and I am unable to learn of the lines of transportation extending to points beyond San Francisco and Portland except in the case of the *Truckee*, which is loading lumber for one trip to some point in Mexico.

There are now plying between points on Tillamook Bay the following boats:

The tugboat, *General Garfield*, 10 tons register, drawing 5 feet of water, towing log rafts and carrying freight. She ascends as far as tide water extends. Two small sailboats carry passengers and some freight. There is also one barge with pile-driver outfit.

The above-mentioned boats and vessels include all that are now or have been in use upon the bay during the year.

The other lines of transportation to and from Tillamook City and Bay are:

Tillamook City to Sheridan via Grand Ronde, 60 miles, triweekly stage. Tillamook City to North Yamhill, Oregon, 42 miles, daily stage. Tillamook City to Hobsonville, Oregon, via Bay City, 9 miles, daily stage. Garibaldi to Nehalem Bar, Oregon, 9 miles, daily stage. All of these stage lines carry the United States mail except from Garibaldi to Nehalem.

INDUSTRIES AND RESOURCES.

The whole of Tillamook County, except a portion bordering on the Nehalem River, is tributary to Tillamook Bay. Its principal resources are now and will be in the future, lumber, canned salmon, farming, dairying, and stock raising. The products, including home consumption for the year 1890–'91, are estimated as follows:

Products.	Amount.	Tons.	Value.
Lumber ..... feet, B. M.	14,230,000	28,460	$13.00 per M.
Canned salmon ..... cases	21,000	756	4.60 per case.
Salt salmon ..... pounds	52,000	26	.02½ per pound.
Butter ..... do	76,000	38	.25 per pound.
Oats ..... bushels	2,500	400	.55 per bushel.
Hay	.....	5,000	8.00 per ton.
Cheese ..... pounds	5,000	2½	.15 per pound.
Beef cattle ..... head	1,200	.....	22.00 per head.
Hides ..... pounds	6,000	3	.06 per pound.
Shingles	600,000	60	2.00 per M.
Brick	10,000	20	8.00 per M.
Apples ..... boxes	3,000	210	2.00 per box.
Wool ..... pounds	22,000	11	.10 per pound.

There are some other small productions, but as they are all consumed on the bay are not estimated.

CITIES AND TOWNS.

There are four small cities and towns situated on and tributary to Tillamook Bay, viz:

Garibaldi, situated three-quarters of a mile inside the bar, with a population of 38. It has two general stores, two hotels, and one salmon cannery. The principal industry is fishing and canning salmon, during which season the population is much increased.

Hobsonville, situated on the east shore of the bay, is 1½ miles south from Garibaldi. It has a population of 112; 1 general store, 1 hotel, post-office, and one salmon cannery. The Truckee Lumber Company's mill is located here, which mill has furnished all the export lumber to date. The principal industries are lumbering and canning salmon.

Bay City, situated on east shore of the bay, 5 miles south of bar; population, 374; June 30, 1890, the population was 80. Bay City has a newspaper, 2 general stores,

post-office, 1 hotel, 1 school building, 1 church, 1 sawmill, capacity 10,000 feet B. M. per day; 1 sash and door factory, 1 hardware store, and storage warehouses and wharves. About $40,000 has been expended in new buildings this year, and there are now being erected 2 stores, 2 hotels, 1 barrel and stave factory, 1 sawmill, besides several dwelling houses. The available resource is lumber.

Tillamook City, county seat of Tillamook County, is situated on Hoquarton Slough, 12 miles south of the bar of Tillamook Bay. It is the oldest settlement and has a population of 650 people.

The county court-house is located at Tillamook City. It has also 1 school building, 1 church, post-office, 1 sawmill with a capacity of 15,000 feet B. M. per day, 1 furniture factory, 6 general stores, 1 jewelry store, 2 fruit stores, 1 boot and shoe store, 1 agricultural implement store, 1 hardware store, 1 furniture store; 2 hotels, 1 bank and 2 newspapers; also 2 blacksmith shops, 2 wagon shops, 2 livery stables, and 3 storage warehouses. The industries are lumbering, agriculture, dairying, and stock-raising. All the agricultural land is tributary to Tillamook City.

Five rivers or streams empty into Tillamook Bay from the east, each having its source in the Coast range of mountains, viz: Miami, Kilchis, Wilson, Trask, and Tillamook rivers. Large bodies of timber land border on the heads of these streams, consisting of spruce, fir, larch, and cedar, a large part of which is tributary to the bay; it has been roughly estimated at 20,000,000,000 feet B. M.

The bottom lands are very fertile and although as yet covered with timber to a great extent, they are the prospective agricultural lands of the county. Much of the timber land is as yet unsurveyed. It is being located as fast as surveyed, and some even before.

The estimated increase of population is 20 per cent for the county since June 30, 1890.

No mines or minerals have yet been discovered tributary to the bay, although it is claimed that indications of coal do exist. Coal in some quantities has been found on Coal Creek, a tributary of the Nehalem River, about 30 miles north of Tillamook City, but no mining has been done.

This information has been derived from various sources; from the county records, records of the various vessels and merchants' books, and by general inquiry and observation.

I have been unable to complete the table through preceding years to any extent, as no records were kept, and the older merchants did not keep books. Many changes have taken place.

No records of the vessels or their cargoes have been kept, not even their arrivals and departures, and my chief source of information was from the freight receipt books of the vessels, which are incomplete and do not extend backward more than two or three years.

Hoping the above may be satisfactory, I remain,

Your obedient servant,

W. H. WOOD.

Capt. T. W. SYMONS,
Corps of Engineers.

There is also given herewith the report of Mr. W. H. Wood on the survey of the inner bay:

TILLAMOOK, *June 30, 1891.*

SIR: I have the honor to submit herewith the following report of survey of the inner harbor of Tillamook Bay, Oregon, made during June, 1891:

Tillamook Bay is situated about 50 miles south of bar of Columbia River, in latitude about 45° 33′ north, longitude 123° 56′ west from Greenwich.

At high tide this bay is a body of water about 7 miles long and from 2 to 3 miles wide, while at low tide it consists of a great sand mud flat, cut by three distinct channels, known as the North, Middle, and South channels. The entrance over the bar is about one-half mile wide.

The South Channel diverges from the Middle Channel near Dicks Point. It is shoal in many places and is not used in navigation.

The North Channel forms near the bar and extends up past Hobsonville and Bay City. It runs out near Shell Point.

The Hobsonville and Bay City vessels use this channel. No fresh-water streams of any extent flow into it above Hobsonville, and from report it is filling up continually.

The Middle Channel is the one used by vessels that ply to Tillamook City, and as the situation now is, any vessel going to Hobsonville or Bay City, in order to reach Tillamook City, must back out to near the bar and take the Middle Channel. This at any stage of the water.

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Flowing into the bay from the north and east are six rivers or streams, the Miami, Kilchis, Wilson, Tillamook, and Trask rivers, and the Hoquarton Slough.

The steam tug *General Garfield*, drawing 5 feet of water, ascends the Tillamook River 3 or 4 miles, while it and the steam schooner *Augusta*, the latter drawing 7 feet 10 inches, both ascend Hoquarton Slough to Tillamook City at high tide. None of the other streams are navigable.

The obstructions to navigation in reaching Tillamook City by way of the Middle Channel are Junction and Dry Stocking bars, separately described as follows:

Junction Bar, as shown on the accompanying map, is situated at a point where the waters of the Wilson River join those of the middle channel of the bay. It is formed by the debris from Wilson River lodging at this point.

To improve same it is proposed to build a dike from the shore near Dicks Point, a distance of 5,000 feet. This will prevent the water from going through the south channel and force the ordinary currents of both channels to flow over this bar, thus keeping it scoured out. The material composing this bar is sand and gravel, apparently very loose and easy to scour.

Dry Stocking Bar is situated where Tillamook River joins Hoquarton Slough, and a short distance below where the Trask River joins the same slough. Tillamook City being situated on Hoquarton Slough about 3 miles above this point, all vessels ascending there have to cross this bar.

I would recommend that a high-water dike be built at this point as shown on map; length 950 feet. Sufficient strength will be required to withstand the winter freshets, which are very severe, as shown by driftwood and other water marks.

This dike will occupy about the same position as did a pile dike that was previously constructed at this place, but which was too weak to withstand the floods, and is now almost entirely destroyed. Of the improvements previously made here, the two spur dikes and revetment on south side of channel still stand and are all sufficient for the intended purpose. This bar is sand and mud, and by confining the channel by this proposed dike, I believe it will scour out 4 or 5 feet deep. At present there is only 6 inches of water on it at low tide.

Accompanying this report are designs for dike and excavation to change channel, throwing the Middle and North channels together, providing such a change is deemed necessary.

By building this dike and excavating through this sand bank it will force the water now flowing in the Middle Channel to flow out through the North Channel, thereby securing one direct navigable channel from the entrance to Tillamook City, and allow the vessels that come to Bay City to proceed direct to Tillamook City. I would recommend the dike to be left 3 feet below high water.

The bar of Tillamook Bay, from all the information I could gather, is not subject to much change, and is in about the same position and condition as previous reports will show.

The four steam schooners that now irregularly cross the bar are the *Augusta*, *Scotia*, *Laguna*, and *Truckee*. Depths in water are respectively 7 feet 10 inches, 11 feet 4 inches, 11 feet 6 inches, and 13 feet 6 inches. They always await favorable winds and high tides. Soundings taken by the captains of each are reported and give various depths on the bar. These soundings as reported will, reduced to lower low-water level, give a mean of 12 feet. The steamer *Truckee* claimed to be bar bound thirty-nine days during April and May, 1891, but all four are going in and out at present without trouble. The bar has only one buoy to mark the channel, and the difficulty seems to be in keeping the channel.

COMMERCE.

The commerce of Tillamook Bay is all confined to the north shore and to Tillamook City on Hoquarton Slough. It consists in canned salmon, lumber, and agricultural products, in amounts and distribution as per my report to you of date June 16, 1891, of "commercial statistics," of Tillamook Bay.

This commerce is capable of much increase, especially the lumber interests, large quantities of timber being found on all the streams, and tributary to the bay are two fish canneries, one at Galibaldi and one at Hobsonville, only one of which was operated during the past year.

The Truckee Lumber Company, located at Hobsonville, are the only exporters of lumber. Their lumber is shipped to San Francisco. Two other mills cut lumber for the local market.

The materials that will be needed in the construction of these several dikes can all be produced here, except iron bolts. Piling in any quantity can be taken out at almost any point, and the sawmills can furnish lumber, while brush, such as alder, hemlock, and spruce boughs, is along all the streams and can be boated to places required. Clay is found in the underlying strata of all the tide lands and can be conveniently placed in works.

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Rock extends along the shore from Memaloose Point to Dick Point in ledges 100 to 200 feet high. Good and convenient quarries of same can be opened up here and loaded on barges at any stage of tide.

I have examined old piling for teredos and find that they do no injury above Hobsonville.

SURVEY.

The field work of this survey was done during the latter part of May and the first of June, being finished June 12, 1891.

The Coast Survey signals were re-located on Memaloose, Dick, Easterbrook, and Shell points, and intermediate signals located by sextant readings from these.

Soundings were taken from a Columbia River fish boat hired for the purpose, two men doing the pulling. The position of the soundings was determined by sextant readings from boat to signals on shore.

In platting the map the points first given above were platted from notes of the Coast Survey triangulation and the intermediates from them by the sextant angles.

A tide gauge was set on wharf near Easterbrook Point and another at Dry Stocking Bar. The readings of high and low water were observed each day and a correction for zero obtained by comparing it with Coast Survey tide tables for the corresponding time, and from this all the soundings were reduced to lower low-water level.

The mean rise of tide at Easterbrook Point is 7.3 feet, and at Dry Stocking Bar 6.6 feet, as so compared and calculated.

It is believed that by placing dikes and excavation as here proposed and shown on accompanying sketches, a minimum depth at low water of from 4 to 5 feet can be maintained in one continuous channel from bar of bay to Tillamook City via Garibaldi, Hobsonville, and Bay City.

Very truly, yours,

W. H. WOOD,
Assistant Engineer.

To Capt. T. W. SYMONS,
Corps of Engineers, U. S. A.

SURVEY OF TILLAMOOK BAR.

In my report on the preliminary examination of Tillamook Bay and Bar there is the following in reference to the bar:

After a full consideration of all available information in regard to Tillamook Bay and Bar I am of the opinion that the present demands of commerce do not require any work looking to the improvement of the entrance to the bay. All accounts agree that this is one of the best small bar harbors on the coast. The bar channel is straight, shifts very little, and has an available depth of 10 feet and more at low water.

I am of the opinion that Tillamook Bay is worthy of improvement to the extent of improving the waters from the entrance to Tillamook City, so that vessels which can safely cross the bar can ascend thereto.

In my project for the expenditure of the money available for "improving harbor at Tillamook Bay" it is recommended among other things that a survey of the bar be made. This project was approved.

This survey was intended to procure the latest definite information in regard to the entrance, and to determine whether any changes of importance had taken place about the entrance since the previous survey of June, 1889.

The last survey was made July 6, 1891, by Mr. John R. Savage, in the steamer *Gen. H. G. Wright.* A plot of the entrance* showing soundings reduced to the plane of the mean of the lower low waters is sent with this report.

This survey and plot shows an excellent entrance, with a depth of 11 feet at mean low water or 17½ feet at mean high water.

At the harbor throat, between Green Hill and Kincheloe Point, the distance between high-water lines is 1,820 feet, and between the 18-foot curves is 500 to 600 feet. The greatest depth shown is 51 feet.

The bar is about 9,000 feet from the harbor throat and it has a navigable passage across it of 11 feet at the mean of the lower low waters.

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*Not reprinted; printed in House Ex. Doc. No. 35, Fifty-second Congress, first session.

The least distance across the bar between 12-foot curves is 1,100 feet, and the distance between 18-foot curves is 3,500 feet.

The survey was made in the summer and shows the location of the bar and channels during the summer, when the northerly winds prevail.

As the winter season approaches and the prevailing winds veer to southerly, the bar and entrance channels move to the northward until they occupy about the position marked on the plot. As winter recedes they return to the position shown.

A comparative chart has been made which shows the surveys of 1867, 1889, and 1891. From this it is seen that the last two surveys give practically identical results.

The survey of 1867 shows the bar and entrance channels somewhat to the north of the location existing at the time of the later surveys, and with a least depth of 15 feet at low water. This would indicate one of two things, either that the bar has shoaled in the last twenty-four years or that in shifting from south to north or north to south a deeper channel than ordinary is sometimes developed.

It is altogether probable that the latter is the case, although the difference may be due to a combination of the two.

Another fact is observed, which is that the bar occupies practically the same position in regard to the sea that it did in 1867, it having neither advanced nor receded.

Mr. John R. Savage, who made the survey of the bar and entrance, reports as follows:

* * * * * * *

I have the honor to submit the following report on the survey of the entrance to Tillamook Bay, Oregon:

Arrived off Tillamook Bay on the steamer *Gen. H. G. Wright* on the morning of Monday, the 6th of July, 1891, but found upon entering only one or two of the former signals for sounding standing, so we started in and ran a line 3,200 feet in length approximately east and west across the northern end of the sand spit, and with that for a base extended a series of triangles which sufficed to locate most of the signals which were being erected as the triangulation was done, but with two signals, viz, "South" and "Beach," it was necessary to run lines from the nearest triangulation points to locate them. About four and a half days were spent in locating and erecting nine or ten signals, most of them temporary, with usually six or seven available men. I took the precaution to erect the signals for the bar soundings first, so that we could take advantage of the prevailing favorable condition of the weather to work on the bar, which we were able to do on two days before the signals were completed.

In all the equivalent of four days were spent in working on the bar, where there were four different sets of intersecting lines run so as to furnish a reliable check on the work, as well as to develop in an expeditious manner all portions of the bar. While sounding on the bar about 780 sextant observations were taken and 3,160 casts of the lead made.

One complete day sufficed to work up the inside of the bay as far as I considered necessary, and about two days were required to locate the high and low water lines, and in each case the mean was taken.

The bar covers a very considerable area, being quite a little larger than the bar at the entrance to Yaquina Bay, and it also shows a very fair depth of water for an unimproved entrance; in the channel, at low water, the least depth being about 11 feet. At the time of writing I have not been able to put the soundings on the map, so this is only an estimate, but it is a conservative one, I think.

The men who are acquainted with this bar, mainly the captains of the vessels passing over it, tell me that during the winter months the channel is very much to the north of its present position; in fact during last winter the two beacons "West Base" and "Spit" were used as a range for the channel by the masters of the vessels crossing the bar, but during the spring the channel gradually shifted to the south until it took its present position, which it has held for about the last two or three months, and is likely, I think, to continue in the same place till fall.

As soon as we tied up in Tillamook Bay I established a tide gauge, which I had read night and day for nearly two weeks, and by a comparison with the time and height of tides as computed from the tide tables, I determined the datum of the

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mean of lower low waters to come on the 2-foot mark of the gauge, which was nailed facing west to a pile on the northeast corner of the Cannery Wharf at Garibaldi.

The total time consumed in making this survey was two weeks.

* * * * * * *

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 11, 1891.

Respectfully forwarded, recommended.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

T T 14.

[Printed in House Ex. Doc. No. 31, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF SWINOMISH SLOUGH, WASHINGTON, WITH THE VIEW OF CONSTRUCTING A SHIP CHANNEL THROUGH THE SAME, CONNECTING SARATOGA PASSAGE AND SKAGIT BAY WITH PADILLA BAY.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 4, 1890.

GENERAL: In compliance with orders contained in your letter of September 20, 1890, I have the honor to make the following report of the preliminary examination of "Swinomish Slough, Washington, with the view of constructing a ship channel through the same, connecting Saratoga Passage Skagit Bay with Padilla Bay, and to report the most suitable and feasible plan for making such improvement, with the cost of the same."

I have lately made an examination of Swinomish Slough in connection with the subject of the bridge of the Seattle and Northern Railroad Company over this slough, and deem no further preliminary examination necessary, as this slough is in my opinion worthy of improvement.

There are three routes for boats passing from the northern portion of the great body of water known as a whole as Puget Sound, to the southern portion thereof.

One way is by keeping through Rosario Straits, through the main sound to the west of Whidby Island and through Admiralty Inlet. The second is by passing through Rosario Straits and Deception Pass into the waters of Skagit Bay, Saratoga Passage, etc.; and the third way is by taking advantage of the navigable waters of Padilla Bay, Swinomish Slough, and Skagit Bay. The first two routes are dangerous for smaller boats, owing to the heavy seas which prevail at times in the main sound to the west of Whidby Island, and to the dangerous passage through Deception Pass.

The route by Swinomish Slough is the most easterly and the safest for the smaller boats which ply on the sound and the many rivers and inlets thereof, as well as the shortest. It is, however, shallow and crooked.

Swinomish Slough is especially valuable for the passage of rafts of logs and lumber from one portion of the sound to the other. It has always been an important highway of commerce, but its relative importance has been changed somewhat of late by the introduction of larger boats on the sound, the building of railroads, and the obstruction

caused by the bridge constructed by the Seattle and Northern Railroad Company across its northern end.

Besides the importance of this slough as a highway for general commerce, it passes through an exceedingly fertile country, the Skagit Delta, the greater part of which has been reclaimed by dikes and brought under cultivation. This Skagit Delta is in many respects the most important agricultural area west of the Cascade Mountains in Washington, and its means of water communication should be carefully guarded and as far as practicable, added to.

The survey for a ship channel will include a length of about 13 miles across the shallow flats of Skagit and Padilla bays, and through Swinomish Slough.

It is estimated that the survey for a ship channel, the preparation of plans and estimates, will cost about $3,000.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 14, 1890.

Respectfully forwarded.

For reasons herein stated, Swinomish Slough is worthy of improvement.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

SURVEY OF SWINOMISH SLOUGH, WASHINGTON, WITH THE VIEW OF CONSTRUCTING A SHIP CHANNEL THROUGH THE SAME, CONNECTING SARATOGA PASSAGE AND SKAGIT BAY WITH PADILLA BAY.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 14, 1891.

GENERAL: The last river and harbor bill contained an item for the examination and, if deemed worthy, survey of "Swinomish Slough, with the view of constructing a ship channel through the same, connecting Saratoga Passage Skagit Bay with Padilla Bay, and to report the most suitable and feasible plan for making such improvement, with the cost of the same."

Under date of September 19, 1890, I was directed to make the required examination, and under date of November 4, 1890, I submitted my report thereon.

By Department letter dated November 21, 1890, I was directed to make the requisite survey.

I now have the honor to submit the following report, with maps,* plans, and estimates.

Map No. 1 is a vicinity map, showing the relations of Swinomish Slough to the principal cities, navigable channels and passes of Puget Sound.

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*Not reprinted; printed in House Ex. Doc. No. 31, Fifty-second Congress, first session.

As shown by this map, there are, in this great body of water known as Puget Sound, three routes for boats passing from the northern to the southern portion, or the reverse.

One way is by keeping in the main sound to the west of Whidby and Fidalgo islands and through Admiralty Inlet. The second is by passing to the west of Fidalgo Island and then through Deception Pass into the waters of Skagit Bay, Saratoga Passage, etc., and the third way is by taking advantage of the navigable waters of Padilla Bay, Swinomish Slough, and Skagit Bay. The first two routes are dangerous for smaller boats owing to the heavy seas which prevail at times in the main sound to the west of Whidby Island, and to the dangerous passage through Deception Pass.

The route by Swinomish Slough is the most easterly, and the safest for the smaller boats which ply on the sound, and the many rivers and inlets thereof, as well as the shortest. It is, however, shallow and crooked in some portions, and the approaches to it are across the shallow flats of Padilla Bay on the north, and Skagit Bay on the south.

Swinomish Slough is the ordinary meeting place of the tides, although at times the tides run in one direction entirely through.

The ordinary rise and fall of the tides in the slough is about 8 feet.

As a general thing throughout the slough there is an abundant depth of water; opposite La Conner there is 10 to 15 feet at low water; just south of La Conner this increases to 34 feet, while at the northern entrance to the "Hole in the Wall" there is a depth of 40 feet at low water.

Where the slough widens out, and especially where the Indians have been in the habit of putting fish traps, this depth decreases so that there is not over 2 feet at low water in any practicable channel. What channel there is, is very crooked.

At the northern end the slough opens out into the flats forming the southern portion of Padilla Bay in the midst of diked land and marshes.

At the southern end of the slough there are two passages connecting the slough with the waters of Skagit Bay. These passages are separated by a rocky island called McGlinns Island.

The east passage is wide and shallow, having nowhere more than 2 feet of water at low water. The west passage between McGlinns and Fidalgo islands is at the narrowest place 220 feet wide, with an ample depth of water for all purposes.

This short and crooked passage is so situated, with high rocky bluffs on either side, that one can not see through from one end to the other. On account of its character it has received and is known by the very descriptive title of the "Hole in the Wall."

This is the passage used almost exclusively by steamers.

EXTENT OF IMPROVEMENT.

Situated as it is, Swinomish Slough is a valuable highway for the local steamboats plying on the sound, for rafts of logs and lumber, and small sailing craft going up the slough and its branches, carrying merchandise and taking out the products of the country.

There is not at present, and I do not believe there is likely to arise, any necessity for large sea-going vessels to pass into or through Swinomish Slough. These vessels, in passing from one portion of the sound to the other, would naturally take the wide and deep waters of Admiralty Inlet or Saratoga Passage.

In fixing upon the extent of improvement proper to be made, consider-

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ation has chiefly been given to the class of vessels before named, *i. e.*, local steamboats, small sailing craft, and rafts of logs and lumber.

The principal use which would be made of the slough would be by the smaller steamboats running to the Nooksack River and the Bellingham Bay towns, Whatcom, Fairhaven, and Sehome, to points in the Skagit River country, the Stillaguamish and Snohomish countries, and to Seattle and Tacoma. These boats draw ordinarily about 3½ to 4 feet.

The sailboats which might use the slough would draw probably not more than 8 to 10 feet.

In deciding upon a depth to be given the navigable pass, this has been fixed at 4 feet below mean low water.

This will give a continuously open passageway for the smaller steamboats, while boats drawing more than 4 feet could always pass through by waiting for the tide.

If in the future, commerce should justify it, this navigable depth could be increased.

The width of the dredged channel has been fixed at 100 feet in order to allow boats or a boat and a raft to pass each other.

Throughout the slough there are places where a greater depth than 4 feet at low water exists naturally, and with much greater widths than 100 feet.

In the long stretch of dredged channel from the southern entrance of the slough to the deep water of Skagit Bay, 2 miles in length, it has been deemed proper to provide a basin where boats could accumulate or lie without interfering with the passage of others. This has been made where the channel passes nearest to Goat Island, and is designed to be widened to 200 feet for 750 feet in length.

As nearly all the traffic into or through the slough will be from north to south, or the reverse, the channel designed to be dredged from the entrance of the slough to the deep water of Skagit Bay is given as much of a southerly trend as practicable. In fixing upon its position, advantage has been taken of a natural channel. The same has been done at the northern end of the slough in locating the channel across the Padilla Flats.

It is feared that if channels are dredged across the Skagit and Padilla Flats they will fill up again unless some means are taken to prevent. With the object of preventing this, a series of dikes shown on the map is proposed. These dikes consist of piles driven about 8 feet apart, and wattled with brush from the bottom to about 2 feet above low water. With the aid of the dikes as located, it is believed that currents sufficient to prevent the deposition of sediment, will be compelled through the dredged channels.

ESTIMATES.

For a channel 4 feet in depth at the mean of the lower low waters, the amount of dredging which will be required for this work in Padilla Bay is 90,000 cubic yards; in Swinomish Slough, 143,000 cubic yards, and in Skagit Bay, 180,000 cubic yards.

The material throughout is sand and mud, all of which can be readily removed by the sand-pump dredges.

The material in Skagit and Padilla bays can be disposed of by conveying it to a distance of 1,000 feet or more through pipes and depositing it upon the mud flats. Most of the material in Swinomish Slough can be disposed of by depositing it in neighboring sloughs or behind

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dikes. A small amount will probably have to be conveyed to a considerable distance and dumped. For this an increased price is estimated.

ESTIMATE.

Dredging:	
Padilla Bay, 90,000 cubic yards, at 20 cents	$18,000
Skagit Bay, 180,000 cubic yards, at 20 cents	36,000
Swinomish Slough, 125,000 cubic yards, at 20 cents	25,000
Swinomish Slough, 18,000 cubic yards, at 30 cents	5,400
Diking:	
Padilla Bay, 6,000 feet wattled pile dike, at $1	6,000
Skagit Bay, 14,500 feet wattled pile dike, at $1	14,500
Swinomish Slough, to retain wasted material, 6,000 feet pile and brush dike, at $1	6,000
Total	110,900
Add 10 per cent for contingencies, superintendence, etc	11,090
Total	121,990
In round numbers	122,000

SHIP CHANNEL.

Although Swinomish Slough is not considered worthy of improvement to the extent of making through it and the adjoining flats of Padilla and Skagit bays a channel for deep sea-going ships, an estimate has been made of the cost of such a channel. This channel as planned, follows approximately the course of the smaller channel shown on the large map sent herewith. It varies from it in being made straighter, and in passing to the east and around McGlinns Island instead of through the passage known as the "Hole in the Wall." This passage would be too tortuous and dangerous for large ships.

While the smaller channel could probably be maintained by suitably directing the tidal currents, it is more than probable that the deep ship channel would require constant dredging to maintain it. To get as great a benefit as possible from the tidal currents in maintaining the channel and to guard against sediment, it would be necessary to build stronger, higher, and closer dikes.

The ship channel estimated for is planned to have a depth of 25 feet at low water, to be 80 feet wide in Swinomish Slough and 150 feet wide in Padilla and Skagit bays.

The estimated cost is as follows:

Dredging:	
Padilla Bay, 2,800,000 cubic yards, at 20 cents	$560,000
Skagit Bay, 2,300,000 cubic yards, at 20 cents	460,000
Swinomish Slough, including disposal of material, 3,200,000 cubic yards, at 25 cents	800,000
Diking:	
In Padilla and Skagit bays, 30,000 feet, at $4 per foot	120,000
	1,940,000
Add 10 per cent for contingencies, engineering, etc	194,000
Total	2,134,000

COMMERCIAL STATISTICS.

Swinomish Slough has been an important highway of commerce in the development of the Puget Sound country. Although this can be asserted without hesitation, the details regarding the commerce are very meager. The use of the slough has been seriously interfered with dur-

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ing the past two years by the bridge of the Seattle and Northern Railroad Company across its northern end. This bridge was built at an angle of about 45 degrees with the current, with a narrow draw span and a draw rest extending almost entirely across the channel. The bridge was complained of, and by direction of the Secretary of War a new drawbridge with a span of 158 feet, giving a clear passage in the direction of the current 100 feet wide, is being built. This it is expected will be completed by January 1, 1892.

The slough has in a few places during recent years also become very shoal, rendering it necessary at all times for boats to wait for high water in order to pass through.

With the removal of the obstruction to navigation caused by the railroad bridge and the deepening of the channel as proposed in this report, there can be no doubt of the greatly-increased use of this short and safe route between the upper and lower portions of Puget Sound.

Aside from the through travel, the improvement of Swinomish Slough will be of immense benefit to the commerce of the Skagit Delta through which it passes. This Skagit Delta is mostly composed of tidal marshes which have been reclaimed by diking and which have an almost fabulous fertility. They are penetrated by several tidal sloughs opening into Swinomish Slough or into Skagit and Padilla bays, which are the principal highways for the removal of their products and the shipping in of merchandise, building material, etc.

The products of the country are chiefly hay, oats, fruits, etc., which find ready and good markets in the larger cities and the lumber camps.

La Conner, the county seat of Skagit County, is situated on Swinomish Slough and is a beautiful little town of about 1,000 inhabitants. The town is old and conservative, having been established in 1869.

The large plat sent herewith shows the slough and the work as projected.

The following statement has been furnished this office by Dr. G. V. Calhoun, ex-mayor of La Conner:

Of the practicability of dredging the Swinomish, nothing need to be said herein, as that point will be fully covered by the report of the engineering corps that made this survey last spring. The next thing to be determined is the necessity for the proposed improvement, which question involves the consideration of safety, distance, and convenience.

All traffic passing from the waters upon which are situated the towns of Padilla, Bay View, Edison, Samish, Anacortes, Guernes, and all points in Whatcom County, to Seattle, Tacoma, Olympia, Coupeville, Oak Harbor, Snohomish, Stanwood, and all other points south of Skagit Bay, is directly affected by the condition of this inside route.

All this traffic must either pass through Swinomish Channel or take the tedious and dangerous outside route west of Fidalgo Island, where it encounters, between Deception Pass and Burrows Bay, the roughest water on Puget Sound or the Straits of Fuca. There the strong tides emerging from Saratoga Passage meet opposing southwest winds, and produce seas against which even the most seaworthy craft can not contend with any degree of safety, and the craft ordinarily plying these waters are utterly unfitted for such an ordeal.

Then at Deception Pass even greater dangers are encountered. The tide, suddenly confined between walls of solid rocks within a very narrow passage, rushes through at a velocity of from 8 to 15 miles per hour, creating great whirlpools and eddies. Very few steamers can make headway against the tide when at its worst, and none can do so with safety.

In attempting the passage against the tide, all steam is necessarily pressed on, and at such a time if the vessel strikes a whirlpool and takes a sheer, only the promptest action can prevent a catastrophe. Thus far, though numerous minor accidents have occurred, the caution of pilots has prevented any very serious mishaps, though hairbreadth escapes have often been reported, and it is generally recognized as an indisputable fact that the sinking of a steamer there would result in a loss of all on board. The steamboat inspectors, comprehending this, have forbidden vessels from attempting the passage except at slack water.

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The inside route, through Swinomish Slough, possesses every advantage over the outside route. It shortens the distance from Skagit Bay and Saratoga Passage to Padilla Bay and the Gulf of Georgia by some 15 miles, and provides a safe sheltered route of sufficient width, free from heavy seas or dangerous tides and rocks, the only obstacles being sand bars, which impede progress.

As before stated, the entire commerce between the northern and southern portions of Puget Sound, dividing on Fidalgo Island, is affected by the condition of the inside route. Such traffic as does not now take this route would do so if the channel was improved to admit of low-tide navigation.

It would be impossible, without a pretty thorough investigation, to form a reliable estimate of the amount of annual tonnage of receipts and shipments.

Owing to the numerous bays, inlets, rivers, and so-called "sloughs" intersecting every portion of the country, all lined with warehouses and granaries, nearly every farmer, logger, and manufacturer, as well as every merchant, is a shipper.

Then, too, we must remember that for every ton of grain or produce shipped out a proportionate amount of provisions, machinery, and merchandise is imported.

For the country situated in the immediate vicinity of this channel and directly tributary thereto, it is estimated that there are shipped annually 20,000 tons of oats (1,250,000 bushels), 20,000 tons of hay, and other products. Over 5,000 tons of merchandise, etc., is imported.

No data is available bearing on the log and lumber shipments, but as logging is even a more important industry than agriculture, some idea may be formed of the quantity of logs and lumber seeking shipment by this route.

As these figures take into consideration only a very small scope of country, perhaps a better idea of the importance of this channel and the necessity of its improvement may be gained by an enumeration of the list of steamers running here regularly or occasionally, as follows:

Steamers making regular trips: Hassalo and Idaho, daily; Mary F. Perly, triweekly.

Steamers regularly engaged in the grain trade: Fanny Lake, E. W. Purdy, L. J. Perry (steam schooner), Utsalady (steam schooner), Maid of Oregon (steam schooner).

Making frequent or occasional trips:

Wasco.	Eliza Anderson.	Glide.
Alki.	Emma Hayward.	J. B. Libby.
Cascade.	Enterprise.	James McNaught.
City of Quincy.	Gem.	Josephine.
Clara Brown.	Geo. E. Starr.	Lilly.
Daisy.	Gleaner.	Brick.
Edison.	Biz.	W. K. Merwin.
Washington.	W. F. Munroe.	Yakima.
Yukon.	Zephyr.	Fairhaven.
J. C. Brittain.	Henry Bailey.	Sehome.
Isabelle.	Margy.	Mame.
May Queen.	Messenger.	Michigan.
Nellie.	Otter.	Saranac.
Seattle.	Skagit Chief.	Susie.

The report of Mr. John R. Savage, assistant engineer, who made the survey, is herewith.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., December 18, 1891.

Respectfully forwarded to the Chief of Engineers, U. S. Army, recommended.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

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REPORT OF MR JOHN R. SAVAGE, ASSISTANT ENGINEER.

CAPTAIN: I have the honor to submit the following report of the survey of Swinomish Slough with a view of constructing a ship channel through the same, connecting Saratoga Passage Skagit Bay with Padilla Bay:

Swinomish Slough is the channel separating Fidalgo Island from the Swinomish flats, and joining Skagit Bay, Saratoga Passage, with Padilla Bay. This slough extends almost due north and south for about 6 miles in longitude 122° 30′ west of Greenwich and in about latitude 48° 25′ north, and affords a direct inside passage for steamers from the upper end of Puget Sound through Saratoga Passage to Bellingham Bay, thus avoiding rough water and the dangers of Deception Pass.

On the north, through Padilla Bay, Swinomish Slough has connection with the Strait of Fuca by way of Ship Harbor and Rosario Strait; and on the south, by Skagit Bay and Saratoga Passage through Deception Pass, there is also connection with the straits; but the main commercial value of this slough is owing to the fact of its being the connecting link for direct water communication between the Bellingham Bay country and all the upper Sound points.

Fidalgo Island, which forms the west shore of Swinomish Slough, is heavily wooded generally, and in the main is more or less broken up and hilly, although towards the north end of the slough there is quite an extent of tide-flat land, from half to 1 mile in width, and about 2½ miles long, of which a part has been reclaimed and is now cultivated by the Swinomish Indians, who own all the portion of Fidalgo Island bordering on the slough. To the east of Swinomish Slough there is a magnificent stretch of farming country, perfectly level, that was originally salt marsh, which has been reclaimed by means of dikes and is now an extremely fertile section, the special products of which are hay and oats, of which very large crops are raised.

These flats vary in width from 4 to 6 miles and extend for many miles to the north and south.

Skagit and Padilla bays are in the main mud flats bare at low water, with a number of small narrow channels running through them, but in a large part of Swinomish Slough there is a very good depth of water. There are a number of shoals or bars, however, nearly bare at low water, which were formed in all probability by the fish traps or dams built by the neighboring Indians some years ago, but these can be easily improved by dredging.

The traffic through the slough has been very light in the last two or three years on account of the Seattle and Northern Railway bridge, which has been a serious obstruction to navigation. It is now, however, being replaced by another bridge with a clear span of 100 feet.

FIELD WORK.

The town of La Conner was the center of operations for this survey, which was started April 23, 1891, with the initial point of the meander line near the lamp designated on the map as "Lamp 100." This line, known as the A line, followed the east shore of Swinomish Slough pretty closely for a distance of about 6½ miles to the bridge and trestle of the Seattle and Northern Railway, from which place another line (the B line) was run south on the west shore of the slough a distance of nearly 7 miles to the north end of the channel known as the Hole in the Wall. These two lines were connected at various points by triangulations and the field work was thus thoroughly checked as the latitudes and departures of the lines were calculated. The location of the shore lines of the slough and the erection and location of the necessary signals for sounding were very quickly done, once the meander lines were run.

A series of triangles was extended through the Hole in the Wall, as chaining was impossible on account of the rocky and precipitous nature of its shores. Here the various signals for sounding were located with reference to the triangulation points or by cuts from two or more of these points; the prominent points of the shore line through this channel were located by sextant observations and the shore line sketched in through these points.

The A line was run 3,600 feet south of its initial point and there was also a short line run on the east shore of McGlinns Island to locate the shore line and the necessary signals for sounding.

The soundings were taken from a small rowboat at equal intervals on diagonal lines across the slough, the points on and the ends of which were located by simultaneous observations with two sextants to the signals established and located on each shore. The soundings were taken in feet and reduced to the mean of the lower low waters. The soundings shown in Skagit and Padilla bays are taken from the work of the U. S. Coast and Geodetic Survey from the survey of 1890.

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TIDE GAUGES, ETC.

Tide gauges were established near each end of the slough and connected by levels and read continuously for a period of about a month; considerable difficulty was experienced in reconciling the daily readings with the corresponding heights and times computed from the tide tables for the Pacific Coast, on account of the distance of the nearest points named in the tide tables from Swinomish Slough. As stated above, the datum to which the soundings were reduced is the mean of the observed lower low waters, which is the plane of reference used by the U. S. Coast and Geodetic Survey.

The tides in Skagit Bay run rather higher than those in Padilla Bay, and the times and heights of high and low water are as a rule, from one-half to three-quarters of an hour later than those in the latter bay, and in consequence of this difference the tide at the Padilla end of the slough begins to ebb before the tide is full at the southern end, which causes the flow of water in the slough at about high water to be in a northerly direction, even after the tide has really begun to fall in all parts of the slough. The tidal currents in Swinomish Slough run with considerable velocity.

BORINGS.

Borings were made with a steel rod at all the shoals in the slough and in nearly every place where excavation is necessary. In nearly every case there was no difficulty met with in working the rod down to more than 10 or 12 feet below the plane of the lower low waters, and in every case the shoals were formed of sand, which I should judge extended as far as the rod penetrated, except in one or two instances when the indications were that gravel was underlying the sand. No borings however were taken at the cut near Whitney's barn, but the material is of an alluvial nature, and, while of course it is not so easy to move as sand, it will cause no particular difficulty in excavating. The material to be moved in the bays is of about the same nature as the above, only probably a little softer.

PROJECT FOR IMPROVEMENT.

The proposed project of improvement consists of a channel 100 feet in width at the bottom, dredged to a depth of 4 feet below the mean of the lower low waters from deep water on the south in Saratoga Passage through Skagit Bay and following closely the eastern shore of Fidalgo Island through the small channel known as the Hole in the Wall, thence through Swinomish Slough, thence by the most direct and economical route practicable to and through Padilla Bay to deep water on the north.

The channel through Skagit Bay leads directly from the Hole in the Wall to a little to the east of Goat Island, where it makes a small turn to the west and follows the small shallow channel across the flats to deep water in Saratoga Passage.

The channel skirting the southern shore of Fidalgo Island and passing into Saratoga Passage just north of Seal Rocks could be improved at a less cost than the one above named, but on account of its being more direct and convenient for the traffic through the slough, the channel to the east of Goat Island has been chosen for improvement.

In Padilla Bay, as shown on the map accompanying this report, the improved channel will follow closely the present channel leading directly from the end of the slough to deep water, although on the score of economy it will be necessary to have this channel more tortuous than is desirable.

Through Swinomish Slough the places where dredging is required are indicated on the map by the hatched channel.

In the slough proper, I think there will be nothing to be feared from the dredged portions filling up again, at least not for several years, and probably very little even then, but the disposition of the material dredged from the slough will require some consideration.

In the outside bays, however, the problem of retaining the depth to which the channel is proposed to be dredged is one of considerable difficulty, while the dredged material could be easily disposed of by pumping behind some sort of a cheap brush dike and allowing the same to settle there.

It is believed that some sort of a training wall or wattled dike, in about the position shown on the map, will be necessary in order to retain the depth in the dredged channels in Skagit and Padilla bays.

At the north end of the slough the material to be dredged and excavated in the cut off, and bar south of the Seattle and Northern Railway bridge can easily be disposed of by pumping it into one of the numerous sloughs about 1,000 feet to the west of the main channel; at the extreme southern end of the slough the material

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excavated could be conveniently wasted behind a brush dike on the tide flat to the west and probably made use of in reclaiming this land for agricultural purposes.

In the 2 miles of the slough from La Conner north there are about 50,000 cubic yards of excavated material to be disposed of, either behind brush dikes above or below high water, or by filling up small sloughs, or by removal on scows and wasting at the nearest available place. There is a stretch of excavation about one-fourth of a mile north of La Conner and about 1,000 feet in length, amounting to nearly 6,400 cubic yards, the excavated material from which can be conveniently wasted between the small island near by, and the mainland, by joining each end of the island with the mainland by a dike to retain the excavated material.

The excavated material in the long stretches near the mouth of White Slough and north of the same could be probably best disposed of by wasting behind a brush dike, constructed along or near the low-water line on the west shore of Swinomish Slough for a distance of about 3,900 feet opposite these shoal parts of the slough.

The disposal of any excavated material in the slough could be safely counted on, not to cost more than 10 cents per cubic yard. This includes disposal by removal on scows, or wasting behind dikes, or by any of the means mentioned, and the disposal of the 18,000 cubic yards remaining out of the above 50,000 cubic yards has been estimated at this, 10 cents per yard cost, without any specified place of deposit.

This channel proposed, from Saratoga Passage to deep water in Padilla Bay, has a total length of about 10.8 miles, with a total cost of $122,000, or a cost per mile of about $11,300.

SHIP-CHANNEL PROJECT.

According to the terms of the law authorizing this survey, an estimate is to be made of the cost of a ship channel through Swinomish Slough to connect Saratoga Passage and Padilla Bay; and a cross section with a depth of 25 feet below the mean of the lower low waters, and with a bottom width of 80 feet, and side slopes of one on one and a half, has been adopted for the project through the slough.

In Padilla and Skagit bays the same depth is used, but the bottom width is enlarged to 150 feet, with the same side slopes as above.

The route chosen for the ship channel is practically the same as that for the 4-foot channel, with the exception that the former passes to the east of McGlinns Island instead of through the "Hole in the Wall;" the ship channel is more direct however, as 2,000 feet has been adopted as the smallest radius.

Through Skagit Bay the route is, as in the 4-foot channel, to the east of Goat Island, where it swings off to the east of McGlinns Island, around which it passes on a curve of 2,000 feet radius and parallels the shore on a tangent for about 2,000 feet, when it reverses on another curve of 2,000 feet radius to the rocky point southwest of La Conner, where there is another reversed curve, this time of 3,000 feet radius and swinging to the west or left, which carries it past La Conner, whence the line is nearly straight or with long tangents, connected by curves of 3,000 feet radius to Padilla Bay, where the natural channels are followed as much as possible to deep water, a distance of about 4 miles from the slough.

The nature of the traffic through Swinomish Slough and from Saratoga Passage to points north thereof will never in my opinion demand a channel of the above cross section, as this class of trade is fully satisfied by steamers of 4 and 5 feet draft, and in consequence of this the estimates for this 25-foot channel have not been prepared with the same care as those for the 4-foot channel, but still they are a close approximation of the cost of such a channel. The price of dredging has been taken at 20 cents per cubic yard, and an allowance of 5 cents per yard has been made in addition to this, to cover the disposal of the material excavated in Swinomish Slough.

The total length of the ship channel from deep water in Saratoga Passage to deep water in Padilla Bay is about 12.5 miles, and the total cost for improving the same would be about $2,134,000, or an average cost of $170,720 per mile.

ESTIMATES.

Channel of 4 feet depth at low water:

Dredging.

Skagit Bay, 180,000 cubic yards, at 20 cents	$36,000
Swinomish Slough, 125,000 cubic yards, at 20 cents	25,000
18,000 cubic yards, at 30 cents, including disposal	5,400
Padilla Bay, 90,000 cubic yards, at 20 cents	18,000
Total dredging	84,400

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Diking.		
Skagit Bay, wattled dike	14,500 feet	
Swinomish Slough, brush dike	6,000 feet	
Padilla Bay, wattled dike	6,000 feet	
	26,500 feet, at $1	$26,500
		110,900
Add 10 per cent for contingencies		11,090
Total		121,990
Ship channel:		
Dredging.		
Skagit Bay, 2,300,000 cubic yards, at 20 cents		460,000
Swinomish Slough, including disposal of material, 3,200,000 cubic yards, at 25 cents		800,000
Padilla Bay, 2,800,000 cubic yards, at 20 cents		560,000
Total dredging		1,820,000
Diking.		
In all, 30,000 linear feet, at $4 per foot		120,000
		1,940,000
Add 10 per cent for contingencies		194,000
Total		2,134,000

Very respectfully, your obedient servant,

J. R. SAVAGE.

T T 15.

REPORT OF BOARD OF ENGINEERS ON PROPOSED SHIP CANAL TO CONNECT LAKES UNION, WASHINGTON, AND SAMAMISH WITH PUGET SOUND, WASHINGTON.

[Printed in House Ex. Doc. No. 40, Fifty-second Congress, first session.]

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, December 15, 1891.

GENERAL: The Board appointed under the act of Congress of September 19, 1890, to select and survey the most feasible location and to estimate the expense of construction of a ship canal to connect Lakes Union, Washington, and Samamish with the waters of Puget Sound, having completed that duty, has the honor to submit the following report:

The Board visited Seattle and carefully examined the vicinity of all the feasible routes for the prescribed canal, and determined the character and extent of surveys and investigations which would be required for a complete understanding and discussion of the problem involved.

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A public meeting was held at the rooms of the Seattle Chamber of Commerce, at which citizens and other interested parties expressed orally their views upon the canal and its various features.

Written communications received by the Board appear as appendixes to the report.

The Board designated Capt. Thomas W. Symons as disbursing officer and as executive in charge of the surveys and preparation of the plans.

The services of Mr. Philip G. Eastwick, civil engineer, were secured, and he was placed in charge of the surveys, with headquarters at Fremont, a suburb of Seattle. Mr. Eastwick's report is herewith.

Accompanying this report is a general map upon a scale of 1 inch to 1½ miles, showing the vicinity of Seattle with Lakes Union, Washington, and Samamish, in their relation to Puget Sound. Upon the same sheet is a map, illustrating in greater detail the canal survey from Puget Sound to Lake Washington, upon a scale of 1 inch to 400 feet, and longitudinal profiles and cross sections along the selected canal routes.

GENERAL DESCRIPTION.

The city of Seattle, the largest city of the State of Washington, is situated upon Duwamish or Elliott Bay, an indentation of the eastern shore of Puget Sound, about half way between the upper or southern end and its junction with the Strait of Juan de Fuca.

In the immediate vicinity of Seattle are the three lakes, Union, Washington, and Samamish, and also Salmon Bay and Smiths Cove, two arms of Puget Sound situated on the line of the projected canal.

LAKE UNION.

Lake Union, which is nearest to the heart of Seattle and to the Sound, is the smallest of these lakes. It has an area of 905 acres, of which 499 acres cover a depth of 25 feet, and with a maximum observed depth of 60 feet. The area of the drainage basin of this lake is 6 square miles.

This lake receives, in addition to the supply of water from its drainage basin, a considerable supply from Lake Washington, through a canal which has been cut through the divide separating the two lakes, and which is used for the passage of saw logs and small vessels.

The outlet of Lake Union is a small stream running from its extreme western end into Salmon Bay. The distance between the lake and the bay is 5,700 feet.

The general and average elevation of the surface of the water in Lake Union is 25.5 feet above extreme low water in Puget Sound, or 7.8 feet above extreme high water.

LAKE WASHINGTON.

Lake Washington, the largest of the three lakes, lies directly east of Lake Union and of Seattle. It is 19 miles long, averages about 2 miles in width, and has an area of 38.9 square miles, or 24,896 acres, of which probably 22,000 acres cover a depth of 25 feet or more.

The depth of this lake is very great. Soundings were not made over the entire area of the lake, but it is stated on apparently creditable

* Not reprinted; printed in House Ex. Doc. No. 40, Fifty-second Congress, first session.

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authority that depths of 600 feet have been observed. The deepest water observed was 150 feet, the length of the sounding line used.

The area of the drainage basin of the lake is 182 square miles. It receives, in addition, the drainage of the basin of Samamish Lake and River, the areas of which amount to 211 square miles.

The outlet of the lake is Black River, which unites with White River, 2.5 miles below the lake, forming the Duwamish River. The Duwamish River follows a tortuous course for about 14 miles and empties into Duwamish Bay. A short distance below the outlet of the lake the Cedar River joins the Black River and flows with it to the Duwamish, except in times of flood in Cedar River, when the waters of Cedar River run partly into Lake Washington, which thus acts as a safety valve to prevent excessive flooding of the Duwamish River valley.

The general elevation of the surface of the lake is 33 feet above extreme low water in Puget Sound, or 15.3 feet above the highest tides. It is 7.5 feet above that of Lake Union.

The most extensive shoals of Lake Washington, where the water has a depth of less than 25 feet, are at the head and at the foot of the lake and in Union Bay. That at the head of the lake, formed by the deposition of sediment brought down by the Samamish River, covers an area of about 300 acres. That at the foot of the lake is evidently formed by the deposition of sediment brought down Cedar River during floods, when a large volume of the waters of that river is emptied into the lake. The area of this shoal is about 300 acres.

The shoal in Union Bay covers an area of 610 acres, almost the entire area of that bay.

The localities of the remaining shoals and their areas, are as follows:

	Acres.
Juanita Bay, north of Kirkland, about	150
Three indentations, south of Houghton, about	200
Meydenbauer Bay, about	75
Mercer Slough Bay, about	200
Island Shoal, about	25
Waterworks Bay, about	25

LAKE SAMAMISH.

Lake Samamish lies to the east of Lake Washington and is separated from it by high ridges. It is about 7¼ miles long, with an average width of a little over 1 mile. The area of the lake is 8 square miles, and that of its drainage basin 102 square miles. Its outlet is through the Samamish River, which, 17 miles in length, flows through a swampy valley into Lake Washington. The observed elevation of the surface of this lake is 41.2 feet above low water in Puget Sound, or 9.6 feet above that of Lake Washington.

The fluctuations of the surfaces of these lakes are moderate and are elsewhere described.

SALMON BAY.

Salmon Bay is an estuary connecting through Shilshole Bay with Puget Sound.

In these bays the tide has a mean range of about 11 feet and an extreme range of nearly 18 feet.

At extreme high tide the level of Salmon Bay is 7.8 feet below the usual level of Lake Union.

This bay has not sufficient depth, even at high stage of tide, for the passage of vessels of considerable draft.

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It will be seen hereafter that the recommended projects provide that the level of the water of Salmon Bay be raised to and maintained at the level of Lake Union, 7.8 feet above extreme high tide. This will necessarily cause the shores of Salmon Bay to be permanently submerged. Part of the submerged land, particularly in the town of Ballard, is occupied by buildings and wharves.

While the raising of the level of Salmon Bay must, to a very large degree, increase values of riparian lands by making a deep-water harbor, yet the submergence of certain lands gives rise to damages and loss, the particular dimensions of which have not been ascertained by the Board. These constitute a liability which is not embraced in the estimates.

The proper disposition of material excavated from the canal prism and from the bays and lakes by dredging, in raising these submerged lands, will be a factor in reducing considerably the measure of these damages.

CANAL TO LAKE SAMAMISH.

By its orders, the Board was directed to include in its survey and estimates, a section of canal connecting Lake Washington with Lake Samamish. It early became evident, however, that there was no real demand for this canal or expectation that it would be given serious consideration. Its cost has been ascertained by survey to be much greater than the cost of the portion connecting Puget Sound with Lakes Union and Washington, and the advantages to be derived from it are very small.

In the general consideration of the subject, therefore, the attention of the Board was, for the reason above stated, more particularly confined to the section connecting Lakes Union and Washington with Puget Sound.

ROUTES.

There are five possible routes for a canal connecting Lakes Union and Washington with Puget Sound.

First. By way of Duwamish Bay and the valley of the Duwamish and Black rivers to Lake Washington and across the Portage from Lake Washington to Lake Union.

Second and third. By way of depressions between the southern part of Lake Union and Duwamish Bay. (These routes were considered twenty years ago by Gen. Barton S. Alexander, and are known in his report as the "Mercer farm route" and the "Tramway route.") Thence from Lake Union to Lake Washington by a canal through the Portage.

Fourth. By way of Shilshole Bay, Salmon Bay, the valley of the outlet of Lake Union to Lake Union, and thence between Lakes Union and Washington, by a canal through the Portage.

Fifth. By way of Smiths Cove to the upper end of Salmon Bay; thence as in the preceding route.

The first route, by the valley of the Duwamish, was soon eliminated from serious consideration by its great cost and other disadvantages.

The second and third routes were practicable twenty years ago, when Seattle was a straggling village, but the land traversed by these routes is now built up with business blocks and residences and the cost of the right of way is prohibitory.

The fourth and fifth routes are entirely feasible. They have received full consideration, and estimates of cost by both routes are submitted.

These two routes coincide in alignment from Lake Washington to

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Salmon Bay; they differ in that one makes the connection with Puget Sound from the head of Salmon Bay, by the lower end of Salmon Bay and Shilshole Bay, and the other through a low gap to Smiths Cove and Duwamish Bay.

In each of the projects, by Shilshole Bay or by Smiths Cove, vessels are to pass from the waters of Puget Sound to Salmon Bay through a masonry lock placed close to the Sound, having a lift varying according to the stage of the tide.

The dimensions of the lock are as follows: Length, 400 feet; net width, 50 feet; depth on the sill at extreme low stage of tide, 16.6 feet.

These dimensions have been the subject of careful consideration in the way of adapting them, at a minimum cost, to present requirements of navigation and to those of the next few years.

The depth on the sill at the lowest high water is 26 feet, so that even in the lowest class of tide there will be two occasions in each twenty-four hours when vessels of 26 feet draft may pass through the locks.

As lower high waters are generally followed by higher low waters, which are but little lower than the preceding high water, there will generally be two or three hours at each high water during which vessels of this draft can pass the locks. The periods for passage of deep-sea vessels of ordinary draft (22 or 23 feet) will last from about half tide on the flood to half tide on the ebb, an interval, including both tides of the day, equal to twelve to fifteen hours. During the remaining portion of the day the lock will pass only vessels of less draft than 22 feet, but at all times there will be an opportunity to lock vessels of 16 feet draft.

This arrangement, which now appears to the Board to afford all needed facility with a minimum of expense, may require to be modified under further consideration of increasing commerce. The sill can be lowered at any time preceding construction, and any desired degree of accommodation can be secured by an increase of cost, which, being confined mainly to the cost of the lock, need not be very great.

As before stated, both projects provide that Salmon Bay shall be raised and maintained to the level of Lake Union.

Both projects include channels excavated through the shoals outside of the tidal locks, 300 feet wide and 26 feet deep at the lowest high tide, that through Shilshole Bay one-half mile, and that at Smiths Cove one-third mile long, and basins at the outlets of the locks 500 feet long and 26 feet deep at extreme low tide, in which vessels may lie to await lockage.

The Shilshole Bay project provides for dredging a channel through Salmon Bay to a point common with the Smiths Cove route.

The Smiths Cove project embraces a canal 80 feet wide on the bottom, 158 feet wide at the water line, and 26 feet deep through the gap between the outer lock and Salmon Bay, and dredging through Salmon Bay to the same common point at its head.

The following features are common to both projects, viz:

A canal 6,700 feet long, 80 feet wide on the bottom, 158 feet wide at the water level, and 26 feet deep, connects the head of Salmon Bay with Lake Union.

This channel is extended through the shoal portions of Lake Union, 200 feet wide, to the portage which intervenes between Lakes Union and Washington. Through this portage a canal 2,600 feet long, 80 feet wide on the bottom, 158 wide at the water line, and 26 feet deep connects Lake Union with Union Bay, a shoal bight in Lake Washington. A lock 400 feet by 50 feet, with a lift of about 7½ feet and depth on sill of 26 feet, overcomes the difference of level between the two lakes, and

a dredged channel 4,600 feet long through Union Bay completes the connection with deep water in Lake Washington.

In addition the Smiths Cove project requires a dam at the narrows of Salmon Bay which shall serve to raise its level to the required height.

The estimated cost of the Shilshole Bay system with masonry locks is $2,900,000, and of the Smiths Cove route $3,500,000.

The Shilshole Bay system costs $600,000 less than that by Smiths Cove. On the other hand, the latter route possesses advantages in that its entrance is in the harbor of Seattle, whereas the entrance to the other is 5½ miles distant, and, secondly, the Smiths Cove entrance and lock are less exposed to bombardment by an enemy's fleet. For these reasons the Smiths Cove route is to be preferred.

By either of these routes there will be added to the commercial facilities of Seattle three fresh-water areas where timber wharves can be constructed and cheaply maintained and where vessels can lie in perfectly quiet water of a constant level.

In the Sound at Seattle the tide has an average range of more than 11 feet and an extreme range of nearly 18 feet. These oscillations of level are all embarrassing to commerce, and wooden wharves are liable to be destroyed by the teredo in a few months. Marine insects are very destructive to piling and other timber placed in the waters of Puget Sound.

Salmon Bay, maintained at the level of Lake Union, will contain 35 acres of water area more than 25 feet deep, and an additional area of 165 acres can be brought to the same depth by a moderate amount of dredging.

Lake Union has an area of 499 acres of a depth of 25 feet, which can, if desirable, be increased by dredging. The total area of the lake is 905 acres.

These two areas combined about equal the total area of the docks of London, and they can readily be made equal by dredging to the area of the Liverpool docks.

Lake Washington area contains 38.9 square miles, or about 25,000 acres, of which about 22,000 acres are covered with a greater depth of water than 25 feet.

In all essential respects the extension from Lake Washington to Lake Samamish conforms to the dimensions of the canal and locks below, connecting Lakes Washington and Union with Puget Sound.

In fixing upon the dimensions of the canal and locks the Board has endeavored to provide accommodation for the present and immediately prospective demands of commerce, and to so leave matters that, if in the future greater accommodations should be required, they can be added without interfering with the usefulness of the present proposed works. The locks are designed to pass the largest type of ships which visit Puget Sound. A list of this shipping, as far as could be ascertained, is here given.

STEAM VESSELS.

Name.	Length of keel.		Beam.		Draft.	Tonnage.
	Ft.	*In.*	*Ft.*	*In.*	*Feet.*	
San Pedro	331	3	42	2	20	3,300
Umatilla	310		40	6	21	2,800
Walla Walla	310		40	6	21	2,300
Willamette	315		39	2	21	2,300
Queen of the Pacific	331		38	5	22	1,800
City of Puebla	320	6	38	6	23	3,000
City of Topeka	198		35	3	17	1,000
Haytien Republic	191	5	36	1	16	875
Al-ki	200	1	38	2	17	1,300

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For extreme length, from 10 to 30 feet must be added to the length of keel noted, and for extreme width 1 foot must be added to the beam. Heights from the water line to tops of masts will range from 120 to 150 feet.

SAILING VESSELS.

Name.	Length of keel.		Beam.		Draft.	Tonnage.
	Ft.	In.	Ft.	In.	Feet.	
Spartan	207	6	40	5	22	2,200
Ivanhoe	202	3	39	3	23	2,200
Germania	170	2	36		19	1,600
Templar	155		35	2	19	1,600
Blue Jacket	193	8	45		21	1,800
Detroit	197		38	5	22	2,200
Levi G. Burgess	217	5	41	2	22	2,500
Alexander McNeil	174	4	36	6	20	1,500
Margaret	201		39	1	23	1,500
Highland Light	194	9	38	1	23	1,900
Commodore	226	9	41	8	24	3,000
Abner Coburn	225		43	2	26	3,300
Elizabeth	231	5	41	8	26	3,100
Alexander Gibson	247	5	42	6	27	3,300
J. B. Walker	247	1	42	2	27	3,300
Daniel I. Tenny	212	4	40	4	24	2,200
Undaunted	207	3	41		23	3,000
Edward O'Brien	259	1	42	2	27	3,000
T. F. Oakes	264	6	42	2	24	2,800
Gen'l Fairchild	203	4	38	8	23	2,400

For length "over all" from 30 to 45 feet must be added to the length of keel noted, and for extreme width 1 foot must be added to the beam. Heights from the water line to top of masts will range from 150 to 200 feet. Top masts can be so lowered as to reduce this height 30 to 40 feet.

From these lists it is seen that all the steamships are readily accommodated, and that all the sailing ships can be accommodated as far as length and width are concerned, and generally with a tug in the same lockage. There are a few ships noted that when fully loaded draw 27 feet.

As the tendency in modern ship building is toward steamships and sailing vessels of smaller draft, it was not deemed necessary to provide at present for the few wooden sailing ships of excessive draft.

There are two classes of ships which can not be passed through the proposed lock, "ocean greyhounds," similar to those plying on the Atlantic, which would be debarred on account of their great length, and the large first class battle-ships and protected cruisers of the Navy, which would be debarred on account of their great breadth of beam. To these may be added the large side-wheel steamers engaged in local traffic on Puget Sound, of the type of the *Olympian*, which is 75 feet wide, guard to guard.

If future developments shall show the desirability of providing for the passage of such shipping, other locks can be built of size sufficient to afford the required accommodation.

The ideal arrangement for this canal would be that laid down for the Manchester Ship Canal, where three locks are planned side by side, one 80 by 600 feet, one 50 by 350 feet, and one 30 by 175 feet.

WATER SUPPLY.

Lake Washington furnishes an ample water supply for the service of the canal.

As it is probable that the lower lock will be used much more fre-

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quently than the upper lock, and as the latter at each lockage passes less water than the former, it is necessary to provide for the passage from Lake Washington to Lake Union of the additional amount of water required for the lower lock. Proper weirs for this purpose are provided at the upper or Portage Lock. If future developments should show the necessity for more water than can well be taken from Lake Washington, an additional supply can be obtained by turning the water of Cedar River into the lake. This can be done at a comparatively small expense.

MODIFICATIONS.

Various modifications of the plan finally fixed upon were considered by the Board of Engineers.

Principal among these was the project of bringing Lakes Union and Washington to the same level, and avoiding thereby a lock at the portage.

Three ways of doing this are available: By lowering Lake Washington to the level of Lake Union; by raising Lake Union to the level of Lake Washington, or by establishing a common intermediate level by raising one and lowering the other.

Upon a full consideration of the advantages and disadvantages which these modifications presented, it was concluded that, owing to the disturbance they would make in values along the shores of the lakes, and to the consequent damages, the best plan would be to leave the lakes at their present levels and connect them by a lock.

Another modification consisted in putting in the outer lock at the head of Salmon Bay and dredging thence a channel through Salmon and Shilshole bays to the deep water of the Sound; but this would largely increase the excavation required, and the project would be deprived of the great benefit of the fresh-water basin of Salmon Bay. This is a modification which might well be considered, however, if the question of damages at Ballard and elsewhere along Salmon Bay can not be satisfactorily solved.

If, in the Smiths Cove route, the question of damages arising from raising and maintaining permanently the waters of Salmon Bay at the level of Lake Union be not capable of satisfactory adjustment, the lower part of that bay, where the greater amount of damages would accrue, can be left in its present condition, and the canal be carried through from the outer lock to the Fremont Cut and Lake Union, and be separated from the lower part of Salmon Bay, in its passage through the head of that bay, by an embankment.

A modification was also considered of substituting, for masonry locks, locks composed partly of masonry and partly of timber. If this were done, there would be a saving of $276,000 in the cost of the outer lock, whether situated at Smiths Cove or Shilshole Bay, and a saving of $253,000 in the cost of the lock at the portage between Lakes Union and Washington.

In the project for the section of canal connecting Lakes Washington and Samamish, it is designed to carry the level of Lake Samamish through the canal to a lock placed near Lake Washington, to overcome the difference of 10½ feet, and to make the canal partly in cut and partly in embankment. This project would have to provide for the drainage of Lake Samamish through the canal. The valley of the Samamish River is occupied by the Seattle, Lake Shore and Eastern Railway, and contains 2,180 acres of valuable land, the surface of which

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is below the level of Lake Samamish. To drain this valley, independent low-water channels would have to be provided.

By placing a dam near the lock at the outlet of the valley, and dispensing with the independent drainage channels, the low lands of the valley would be flooded.

The disturbance of values and resultant damages due to the flooding of the valley would largely exceed the cost of drainage by the independent channels.

As the building of this section of canal has not been seriously contemplated, the time and care applied to making the plans and estimates for it have not been as great as to the other portion from the Sound to Lake Washington.

The project of the Board contemplates the raising of the waters of Salmon Bay to the level of Lake Union, 7½ feet above the extreme high tide level, and permanently maintaining them at this elevation. This will flood an area of 187 acres above high tide, by far the greater part of which is about the head of Salmon Bay, above the town of Ballard.

There are some improvements about the town of Ballard which will be interfered with by this raising of the water, and the estimates include the necessary work required to raise the buildings, mills, etc., so interfered with.

It is proposed to utilize to as great an extent as possible, the material excavated from canal and channels in filling up to the necessary level the lands overflowed.

No other provision is made for these lands, as it is believed that the great additional value given to them by the construction of the canal, basins, etc., would more than compensate the owners for the trouble and expense which they might be put to in raising them to proper grade.

It is proposed to make, as previously stated, the channel from the outer lock to deep water in the Sound, 300 feet wide and 26 feet deep at the lowest high water.

No provision is made for maintaining this channel, as it can only be definitely ascertained by experience whether any works of maintenance will be required.

If it be found, after the canal is put in operation, that this channel shoals up, it can be maintained either by dredging or by building jetties to exclude drift, or by both.

ESTIMATES.

The projects contemplate the construction of masonry locks, each provided with an upper and a lower lock-gate and a guard-gate, all constructed of steel, with all necessary capstans, and inlet and outlet valves, with hydraulic engines to operate them, the power to be supplied by turbine wheels; with dwelling houses for keepers; with electric lighting plant for lighting the lock; with stone revetted wasteweirs, etc.

The canal proper in upland cuts is to have a bottom width of 80 feet and a surface width of 158 feet; the channels in Salmon Bay, Lake Union, and Union Bay are to have bottom widths of 200 feet, and the approach from deep water in the Sound to the outer lock is to be 300 feet wide.

Smiths Cove route.—The total estimated cost of the complete project for the ship canal from deep water in Duwamish Bay, via Smiths Cove, the head of Salmon Bay and Lake Union, to Lake Washington, is $3,448,261.23; in round numbers, $3,500,000. This cost can be materially reduced in two ways:

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First, by building, instead of a double-track canal in which ships can pass each other, a single-track canal in the three portions of the canal excavated in the uplands, namely, from the outer lock to Salmon Bay, from Salmon Bay to Lake Union, and from Lake Union to Lake Washington. The canal designed and for which the estimates are made is 80 feet wide on the bottom and 158 feet at the water line. By reducing the width at bottom to 50 feet and at the water line to 128 feet, ample provision would be made for the passage of ships from one basin to another and out to the Sound, and the additional width can be given when demanded by the increase of commerce.

In the same manner the excavated channels in Salmon Bay, Lake Union, and Union Bay could be reduced from 200 feet in bottom width to 150 feet without any immediate disadvantage and the greater width be provided for when demanded by the increase of commerce.

By thus reducing the width of the canal and basin channels, a saving in excavation of 800,000 cubic yards can be made, equivalent to $400,000, reducing the estimated cost of the work to $3,100,000.

A second way of reducing the estimated cost would be by the substitution of composite locks of masonry and timber for masonry locks. In this way a saving of $529,000 could be effected, still further reducing the cost to $2,571,000.

Shilshole Bay route.—The total estimated cost of the complete project for the ship canal from deep water in Puget Sound via Shilshole and Salmon bays and Lake Union to Lake Washington is $2,902,859.23, or in round numbers $2,900,000.

As in the other case, the estimated cost of $2,900,000 can be materially reduced in two ways.

First, by reducing the upland cuts from a bottom width of 80 feet to a bottom width of 50 feet, and the dredged channel through Salmon Bay, Lake Union, and Union Bay from 200 feet to 150 feet width at bottom.

This would reduce the amount of excavation 670,000 cubic yards, equivalent to $335,000, and the total estimated cost to $2,565,000.

The second way of reducing the cost would be by substituting composite locks of masonry and timber for masonry locks. In this way a saving of $529,000 could be effected, reducing the total estimated cost still further to $2,036,000.

The estimates for both routes include the securing of sufficient land for the full width of canal.

The following is a summary of the estimates:

Smiths Cove route:	
Double-track canal with masonry locks	$3,500,000
Double-track canal with composite locks	2,971,000
Single-track canal with masonry locks	3,100,000
Single-track canal with composite locks	2,571,000
Shilshole Bay route:	
Double-track canal with masonry locks	2,900,000
Double-track canal with composite locks	2,371,000
Single-track canal with masonry locks	2,565,000
Single-track canal with composite locks	2,036,000

The estimated cost of the canal to connect Lakes Washington and Samamish is $4,927,230.

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PHYSICAL DATA.

The following table gives in a convenient form the principal physical data connected with the project:

Elevations:		
Extreme low tide, Puget Sound	feet	0
Mean low tide, Puget Sound	do	3.3
Lowest high tide, Puget Sound	do	9.4
Mean high tide, Puget Sound	do	13.6
Extreme high tide, Puget Sound	do	17.7
Lake Union, lowest water observed above extreme low tide of Puget Sound	feet	25
Lake Union, highest water observed above extreme low tide of Puget Sound	feet	26.1
Lake Washington, lowest water observed above extreme low tide of Puget Sound	feet	31.6
Lake Washington, highest water observed above extreme low tide of Puget Sound	feet	33.1
Lake Washington, highest water flood marks above extreme low tide of Puget Sound	feet	34.4
Lake Samamish, lowest water observed above extreme low tide of Puget Sound	feet	41.2
Lake Samamish, highest water observed above extreme low tide of Puget Sound	feet	43.1
Divide between Smiths Cove and Salmon Bay, above extreme low tide, Puget Sound	feet	49
Portage Divide, between Lakes Union and Washington, above low water of Lake Washington	feet	30
Divide on "Mercer Farm Route," above Lake Union	do	108
Divide on "Tramway Route," above Lake Union	do	105
Areas, depths, etc.:		
Salmon Bay:		
Total water area	acres	318
25 feet and over in depth	do	35
Less than 25 feet in depth	do	283
Lake Union:		
Total water area	do	905
25 feet and over in depth	do	499
Less than 25 feet in depth	do	406
Greatest depth	feet	60
Lake Washington:		
Total water area (about)	acres	24,896
25 feet and over in depth (about)	do	22,000
Greatest depth (probably)	feet	600
Lake Samamish:		
Total water area	acres	5,120
25 feet and over in depth (about)	do	4,000
Less than 25 feet in depth	do	1,120
Greatest depth (about)	feet	100
Lake Union Drainage Basin	sq. miles	6
Lake Washington Drainage Basin	do	182
Samamish River Drainage Basin	do	109
Lake Samamish Drainage Basin	do	102
Distances:		
Deep water to outer lock, Shilshole Bay (from 30-foot curves)	feet	2,400
Deep water to outer lock, Smiths Cove (from 30-foot curves)	do	2,000
Outer lock, Shilshole Bay to head Salmon Bay	do	12,900
Outer lock, Smiths Cove to head Salmon Bay	do	12,000
Head Salmon Bay to Lake Union, "Fremont Cut"	do	4,800
Through Lake Union to upper lock	do	13,300
Upper lock through Portage Canal to Union Bay and Lake Washington	feet	3,100
Through Union Bay to deep water in Lake Washington	do	4,600
Lake Washington to Lake Samamish	miles	13
Samamish River, total length	do	17
Lake Washington, down Black to Cedar River	do	¼
Lake Washington, down Black to White River	do	2¼
Duwamish River from junction of Black and White rivers to Duwamish Bay, length of valley	miles	8
Duwamish River, length of river	miles	14

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Distances—Continued.		
Outlet Duwamish River across tide flats to deep water	do...	1¼
Diameter Union Bay	do...	1¼
Duwamish Bay to Lake Union by "Mercer Farm Route"	feet..	5,100
Duwamish Bay to Lake Union by "Tramway Route"	do...	6,310
Dimensions:		
Approach to outer lock, depth below lowest high water	feet ..	26
Approach to outer lock, width at bottom	do...	300
Outer lock:		
Width of gates, clear width	do...	50
Length of lock chamber, clear length	do...	400
Depth of lock, clear depth	do...	26
Lift of lock	do...	7.3–26.1
Lift of lock, average	do...	14.4
Channel in Salmon Bay, Lake Union, and Union Bay, depth	do...	26
Channel in Salmon Bay, Lake Union, and Union Bay, width at bottom	feet..	200
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, width at bottom	feet..	80
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, width at water line	feet..	158
Canal excavated in uplands, Smiths Cove Cut, Fremont Cut, and Portage Cut, depth	feet..	26
Upper lock, same dimensions as outer lock.		
Lift of upper lock, maximum	do...	8.1
Lift of upper lock, average	do...	6.6

Very respectfully, your obedient servants,

G. H. MENDELL,
Colonel, Corps of Engineers.
THOS. H. HANDBURY,
Major, Corps of Engineers.
THOMAS W. SYMONS.
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. PHILIP G. EASTWICK.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, September 14, 1891.

SIR: Under your instructions I have made surveys upon which to base a project, and estimates, for the construction of a canal to connect Lakes Union, Washington, and Samamish with Puget Sound, as authorized by the river and harbor act of September 19, 1890, and respectfully submit the following report:

Accompanying this report is also submitted a sheet upon which is drawn to a scale of two-thirds of an inch to 1 mile, a general map showing the position of the lakes and their surroundings with reference to Puget Sound; and a map to a larger scale showing more in detail that part of the selected canal route between Lake Washington and Puget Sound.

On the general map are shown the respective drainage basins of the three lakes and of the Samamish River, the link connecting Samamish Lake with Lake Washington.

The following table shows the relative elevations of the surface of the water in the lakes and of the high and low water planes of Puget Sound, the plane of extreme low water, as deduced from observations extending over six weeks, being taken as the plane of reference.

		Feet.
Lake Samamish	Highest observed	43.1
	Lowest observed	41.2
Lake Washington	Highest flood marks	34.4
	Highest observed	33.1
	Lowest observed	31.6
Lake Union	Highest observed	26.1
	Lowest observed	25.0
Shilshole Bay	Extreme high tide	17.7
	Mean high tide	13.6
	Lowest high tide	9.4
	Mean low tide	3.3
	Extreme low tide	0.0

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The basins of Lake Samamish, Samamish River, and Lake Washington together form one greater basin, having its outlet at the south end of Lake Washington through Black and Duwamish rivers to the waters of Puget Sound at the head of Duwamish or Elliott Bay.

This larger basin is separated from the basin of Lake Union and from Puget Sound on the west by a high ridge, with undulating surface, extending from Black River northward. Through this ridge is a low depression at a point where the shore lines of Lakes Washington and Union approach each other. At this place the width of the ridge is a little over one-third of a mile, and the greatest elevation 30 feet above the low-water plane of Lake Washington. Through this ridge, locally known as "The Portage," a narrow canal furnished with a lock has been made, and through this, in the operation of the canal, a small part of the water of Lake Washington is passed into Lake Union.

In the larger drainage basin, the sub-basins of Lake Samamish and of Samamish River are separated from that of Lake Washington by a high and broad ridge which terminates at its north end at the head of Lake Washington, where the Samamish River empties into that lake. Through this ridge no available canal route is offered. The only available route for a canal to connect these two lakes is through the valley of the Samamish River.

This valley is nearly thirteen miles long as measured on a practicable canal line. Owing, however, to the sinuosities of the river, its length is increased to seventeen miles.

The upper part of the valley is broad and flat and much of it so low as to be at all times marshy and frequently flooded. Descending toward Lake Washington, the valley narrows, and at three places, where the flanking hills throw out spurs into the low land, the thread of the valley is very abruptly deflected.

An extension shoal at the head of Lake Washington, through which a canal would pass, will increase the total length of the canal and its approaches to a little over 14 miles.

The Samamish River at low water is a stream of small velocity, averaging about 50 feet in width with a depth generally of from 6 to 8 feet. Near its head are a few reaches of rapid water passing over gravel bars where the depth is decreased to 3 feet in a narrowed channel.

Black River, the natural outlet to Lake Washington, joins with White River at a distance of 2½ miles from the lake, the confluence of these two rivers forming the head of the Duwamish River. Black River passes generally through a contracted depression in the edge of a broad valley, receiving the waters of Cedar River about a half-mile below the outlet of Lake Washington. It carries the level of Lake Washington to near the junction of Cedar River, where, after receiving the waters of that river, it passes with a current of about 5 miles per hour during the low-water stage, over a shoal and rocky bottom for a distance of over half a mile. Below this rapid a strong current continues to the head of the Duwamish. The river is from 50 to 150 feet wide.

Duwamish River flows in a very sinuous course through a broad flat valley to the head of Duwamish or Elliott Bay. On an air line between the head of the river and Duwamish Bay the distance is about 8 miles. By the sinuosities of the river, however, the distance is increased to 14 miles. The floor of the valley is low and flat, and subject in most parts to overflow during freshets. The repeated overflows have, by the deposit of sediment, raised the surface of the valley nearest to the river, to an elevation higher than that of the more distant part near the base of the flanking hills, a slightly elevated river ridge having been formed.

From the outlet of Duwamish River, at the high-water line of Duwamish Bay, to deep water of the bay, there is a distance of 1½ miles over a shoal mud flat, most of which is bare at low water.

It will thus be seen that the length of a canal from Lake Washington to deep water of Puget Sound will be at least 12 miles, with such increase as may be due to any obstructions to direct alignment that will upon definite survey be encountered.

With locks so located upon the line of the canal that the excavation would be a minimum, there would be at least 7,000,000 cubic yards of excavation for a canal prism having a width at bottom of 80 feet, and at water surface of 160 feet, and carrying a depth of water of 26 feet.

But owing to the large volume of water which, at the time of floods, enters the Duwamish River from Cedar and White rivers, an enlargement of the canal to a very considerable magnitude would be required, that the current induced by the freshets would be reduced to a velocity that would not materially impede navigation or threaten destruction to the embankments of the canal; or such flood waters must be carried off in separate channels exterior to the canal prism.

Under any circumstances the volume of excavation would be largely increased over that stated. This increase would probably equal or exceed in quantity that of

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the canal prism, making the total excavation for a canal by this route exceed 14,000,000 cubic yards.

Much of the excavation through the valley of the Black River (which, however, is a small part of the entire excavation) would be of rock. The large mass, however, of the entire excavation will probably be of easy-cutting sedimentary material.

White and Cedar rivers at the time of freshets carry down large amounts of gravel, sand, and mud, which, being deposited in the lower channel, will require to be periodically removed.

Without attempting to make a close estimate of the cost of a canal over this route, involving not only the excavation, but also the construction of water-tight embankments throughout nearly the entire length of the canal, of one or more locks with a total lift of 34 feet, and of waste weirs, the compensation for land occupied, and other expenses incidental to the work, it may safely be assumed that the cost of construction and of maintenance will be so far in excess of that of a canal via Lake Union and Salmon Bay, and the benefits to commerce less advantageous, that the further consideration of this project is not warranted.

In the western shore of Lake Washington, nearly midway of its length, is an opening about 2,000 feet wide between low headlands leading into Union Bay. This bay is nearly circular in shape and about 1¼ miles in diameter. Its extreme western margin approaches the shore line of the eastern arm of Lake Union at a place heretofore referred to as "The Portage," where the divide is narrow and low. This place offers the only remaining possible canal outlet from Lake Washington in the direction of Puget Sound.

Union Bay is very shoal throughout nearly its entire extent, and has a bottom of soft ooze of considerable depth. A canal line through the bay would cut into this material for a length of 4,600 feet.

The canal cut through "The Portage" will be 2,600 feet long, and the material, as indicated by the walls of the existing canal, will be cement gravel and hardpan.

In Lake Union, from the western end of "The Portage" cut, to a depth of 26 feet, the distance is 5,600 feet. Near "The Portage" on this line the descent is abrupt to a depth of 18 feet at a distance of 700 feet. Over the remaining distance to 26 feet depth the bottom falls gradually with but little undulation.

The low-water level of Lake Washington is 6.6 feet higher than that of Lake Union. The flood marks of Lake Washington indicate a level 2.8 feet higher than the low-water level.

Between Lake Union and Puget Sound is a high ridge cut by a low and wide valley at the western end of the extreme western arm of the lake. Through this valley the natural drainage of the lake finds its outlet to the head of Salmon Bay, an arm of Puget Sound.

At the extreme south end of the lake are two depressions in the ridge separating the lake from Duwamish Bay. These depressions are referred to in the report of General Alexander, dated December 15, 1871, where they are designated as possible canal routes. They are in that report designated, respectively, as the "Mercer Farm Route" and the "Tramway Route." The distance between the lake and bay by the former route is 5,100 feet, and by the latter route, 6,310 feet, and the maximum elevations 108 and 105 feet respectively.

At the time of this first examination of these routes (nearly twenty years ago) the land traversed by them was for the most part wild and unimproved, with an occasional clearing which added but little to its value. Much of the land in the vicinity was then, and remained for many years later, public land subject to entry under the homestead and preëmption laws, not having sufficient value to attract the attention of settlers. The shores of the lake and bay at the termini of these routes were unimproved and unoccupied except by the cheaply constructed and temporary landings of the Seattle Coal and Transportation Company, who at that time operated a tramway over one of the routes in the transportation of coal, the need of which would have been obviated upon the construction of a canal. Seattle at that time was a village covering a very small area and having a population of about 1,200. It was surrounded by dense forests traversed by few wagon roads and trails.

According to the recent census, the city of Seattle has a population of 45,953. The improvements of the city of Seattle now extend to, and far beyond, the location of these canal routes. Streets have been laid out, opened, and improved; costly manufacturing establishments, stores, warehouses, and dwellings have been erected, and the district changed to busy industrial adjuncts to Seattle, or to residential suburbs. The water fronts on Lake Union and on Duwamish Bay are occupied by industrial establishments, warehouses, and shipping wharves.

As a result, the value of the land traversed by these routes has during the past twenty years increased to figures of large proportions, and the conditions which warranted the consideration of a project for the construction of a canal over either of the routes are now so radically changed that the consideration of such a project may with

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reason be abandoned in favor of the route via the valley of the natural outlet of the lake to the head of Salmon Bay.

The last named valley extends from Lake Union to the head of Salmon Bay, a distance of 6,700 feet. The floor of the valley is broad and low, its elevation at the upper end being but a few feet higher than the low-water level in Lake Union, and below that level at, and near Salmon Bay. The entire area of the floor of this valley has been laid off into town lots upon which a few cheaply constructed buildings and a few sawmills have been erected, the removal of some of which will be required upon the construction of a canal.

To the north of this valley and of Salmon Bay the hills rise to a high and extensive undulating plateau. To the south lies Duwamish or Elliott Bay, separated by a high and broad plateau through which is a low, narrow, and straight gap connecting the head of Salmon Bay with Smiths Cove, an indentation in the north end of Duwamish Bay. Through this gap the distance is 5,000 feet between high-water lines and the maximum elevation, 49 feet above extreme low water of Puget Sound. In both Smiths Cove and Salmon Bay are extensive mud flats, bare at low water. Through this gap the lines of the Seattle, Lake Shore and Eastern Railway Company, and of the Seattle and Montana Railway Company, pass on their routes from Seattle to the north and east.

From its head Salmon Bay extends in a westerly direction a distance of 2 miles to Puget Sound, at the inner edge of Shilshole Bay, from whence the distance to deep water is nearly one-half mile over a sand beach, much of which is above the level of the low-tide plane.

Estimates of the cost of construction have been prepared for a canal connecting the lakes with Puget Sound, both on the routes from Shilshole Bay and from Smiths Cove to the head of Salmon Bay, and thence by a common route via Lake Union and "The Portage" to Lake Washington, and also from Lake Washington to Lake Samamish via the valley of Samamish River. These estimates are given in detail in the Appendix and are stated in their totals, as follows:

TOTALS OF ESTIMATES.

A. From Puget Sound to head of Salmon Bay:	
1. Via Shilshole Bay	$1,019,319.51
2. Via Smiths Cove	1,564,721.51
B. From head of Salmon Bay to Lake Union:	
Via the valley of the outlet to the lake	506,000.00
C. From Lake Union to Lake Washington:	
Through "The Portage"	1,122,706.75
D. From Lake Washington to Lake Samamish:	
Via the valley of Samamish River	4,927,230.00
To these estimates of the cost of construction between Puget Sound and Lake Union, either via Shilshole Bay or Smiths Cove, must be added the estimated cost of changing the location of the Seattle, Lake Shore and Eastern and of the Seattle and Montana railways.	89,832.97
And of raising mills, dwellings, stores, etc., in the town of Ballard	165,000.00

Detailed estimates of these are given in the Appendix.

In case of the construction of the canals by both the Shilshole Bay and Smiths Cove routes, $27,500 should be deducted from the summary estimate for the cost of the dam at the narrows in Salmon Bay, which in that case will be omitted.

The foregoing estimates are summed up for different combinations as follows:

I.—*Puget Sound to Lake Union.*

a. Via Shilshole Bay:	
Puget Sound to head of Salmon Bay	$1,019,319.51
Head of Salmon Bay to Lake Union	506,000.00
Change of railway location	89,832.97
Raising mills, etc., in Ballard	165,000.00
Total	1,780,152.48
b. Via Smiths Cove:	
Puget Sound to head of Salmon Bay	1,564,721.51
Head of Salmon Bay to Lake Union	506,000.00
Change of railway location	89,832.97
Raising mills, etc., in Ballard	165,000.00
Total	2,325,554.48

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c. Via Shilshole Bay and Smiths Cove combined:

Puget Sound to head of Salmon Bay, via Shilshole Bay		$1,019,319.51
Via Smiths Cove	$1,564,721.51	
Less cost of dam	27,500.00	
		1,537,221.51
Head of Salmon Bay to Lake Union		506,000.00
Change of railway location		89,832.97
Raising mills, etc., in Ballard		165,000.00
Total		3,317,373.99

Adding to each of these estimates the estimated cost of construction between Lakes Union and Washington, the following estimates are obtained:

II.—*Puget Sound to Lake Washington.*

a. Via Shilshole Bay	$2,902,859.23
b. Via Smiths Cove	3,448,261.23
c. Via Shilshole Bay and Smiths Cove combined	4,440,080.74

And if to these last estimates the estimated cost of construction between Lakes Washington and Samamish be added, the entire cost of the canal connecting Lakes Samamish, Washington, and Union with Puget Sound under the different projects is obtained as follows:

III.—*Puget Sound to Lake Samamish.*

a. Via Shilshole Bay	$7,830,089.23
b. Via Smiths Cove	8,375,491.23
c. Via Shilshole Bay and Smiths Cove combined	9,367,310.74

All estimates through the higher lands are based upon excavation of a canal prism having a cross section as shown on the accompanying map; the bottom of the canal to be 80 feet wide and side slopes 1½ horizontal to 1 vertical up to the tow path or lower berme, 32 feet above the bottom; the depth of water in the canal to be 26 feet. In the deeper excavation the slopes above the towpath or lower berme to be 1 horizontal to 1 vertical, with narrow bermes at each 20 feet of excavation.

Through Salmon Bay, interior to the outer locks and through the shoals in Lakes Union, Washington, and Samamish, and in Union Bay, the estimates contemplate the excavation of a channel 200 feet wide carrying 26 feet depth of water. Exterior to the locks of Salmon Bay and Smiths Cove the width of channel is increased to 300 feet, with a depth of 26 feet of water at the lowest high tide.

The locks at the outlet of the canal systems both at Salmon Bay and Smiths Cove are to be placed near to Puget Sound, raising the water in the canal between them and Lake Union to the level of the lake. Each of the locks will have a lift of 16.7 feet at low high water and 26.1 feet at extreme low water.

The lock at the Portage provides for a lift of 8.1 feet, the difference of level between the low-water level of Lake Union and the extreme flood level of Lake Washington. This lock is to be placed at the head of Lake Union and adjoining the excavation at the Portage.

The lock between the waters of Lakes Washington and Samamish provides for a lift of 10½ feet, the difference of level between the low-water level of Lake Washington and the high-water level of Lake Samamish. Upon the excavation of the canal in the Samamish River Valley, a freer outlet of the waters of Lake Samamish will be offered, and the rise in that lake, which is caused by the present restricted channel, will be reduced, thereby lessening the lift required in the lock. This lock is located at the outlet of the river at the head of Lake Washington.

The projects contemplate the construction of masonry locks provided with an upper and a lower lock gate and a guard gate constructed of steel, all necessary capstans, inlet and outlet valves, and hydraulic engines to operate them, the power to be supplied by turbine wheels. The locks are to have a clear width of 50 feet at the gates and in the main lock prism, and a length to accommodate vessels 400 feet long.

Independent estimates have been made for all locks wherein the masonry has been, as far as practicable, replaced by structures of timber.

Substituting such structures, the cost of the respective locks will be reduced as follows:

	Difference in cost.
Lock at outlet at Salmon Bay	$276,000
Lock at outlet at Smiths Cove	276,000
Lock at the Portage	253,000
Lock at head of Lake Washington	271,000

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In the following table are given the lengths of the several reaches of canal on the route via Shilshole Bay, including the lengths of the intermediate reaches in Lakes Union and Washington, where no improvements are required.

	Miles.
From deep water of Puget Sound to head of Salmon Bay and point common with Smiths Cove Canal	2.84
Fremont Canal and approaches	1.02
Lake Union (no improvement required)	1.50
Portage Canal and approaches	2.42
Lake Washington (no improvement required)	8.25
Samamish Valley Canal and approaches	14.07

From these data the following table of lengths is deduced:

	Miles.
From Puget Sound to Lake Union	3.86
From Puget Sound to Lake Washington	7.78
From Puget Sound to Lake Samamish	30.10

The length of the reach from deep water of Puget Sound at Smiths Cove to a connection with the route via Shilshole Bay, at the head of Salmon Bay, is 2.59 miles.

No data concerning the rainfall in the immediate vicinity of the area of the drainage basins of the lakes are to be obtained. The nearest approach to such information is furnished by the continuous observations of rainfall since the beginning of 1878, made on Bainbridge Island, which lies at the west side of Puget Sound, about 12 miles due west of the middle of Lake Washington.

The following table gives the total amount of rainfall for each year at the locality named:

Year.	Rainfall.	Year.	Rainfall.
	Inches.		*Inches.*
1878	46.38	1885	43.68
1879	64.87	1886	34.92
1880	49.35	1887	40.09
1881	53.82	1888	39.97
1882	42.53	1889	27.88
1883	34.85	1890	30.26
1884	34.03		

The record for the year 1890, by months, is as follows:

Year.	Rainfall.	Year.	Rainfall.
	Inches.		*Inches.*
January	7.71	July	0.50
February	4.88	August	0.26
March	2.90	September	0.07
April	1.54	October	3.09
May	1.03	November	0.74
June	1.65	December	5.89

From the first table it will be seen that the average rainfall per annum for the thirteen years is 41.74 inches, and for the last five years, 34.62 inches.

The second table shows that the greatest precipitation occurs in December and January, when nearly 45 per cent of the whole annual rainfall is precipitated, and that the months of July, August, and September cover a dry period when the precipitation is less than 0.3 per cent of the total.

The data upon which to estimate the amount of the evaporation from the surface of the drainage basins and lakes are not obtainable, but from the fact that at all times, except when checked by a rise in the waters of Cedar and White rivers, there is an outflow from Lake Washington through Black River, it is evident that the supply from the drainage basins exceeds at all times the evaporation. The amount of this excess during the dry seasons it is impossible to determine upon any data at present available.

An examination of the tide tables for the Pacific coast, for 1891, shows that the average height of all the tides during the months of July, August, and September, referred to the plane of extreme low water, is 10.6 feet, and, as the low-water level of Lake Union, after the construction of the canal, will be 25 feet above the same plane, the average lift of the lock, either at Salmon Bay or Smiths Cove, will be 14.4 feet.

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The lift of the lock at the Portage at the low-water stage in both lakes is 6.6 feet, and as the length and width of the prism of this lock are the same as those of the locks at Puget Sound, the relative amounts of water discharged in one lockage at each lock will be in proportion to the lift. The lock at Puget Sound will consequently require for the lockage of a vessel an average of nearly 2.2 the amount of water that is required for the same work at the Portage lock.

As the supply of water from the basin of Lake Union is, during the summer months, practically nothing, all the water required for the lockage at the outer lock during that period must be drawn from Lake Washington.

With a number of lockages at the Portage equal to that at the outlet, the volume of water supplied by the former lock will be less than one-half that required for the latter, and the deficiency must be supplied from Lake Washington by a channel other than that through the Portage lock. In the projects upon which the estimates have been based this is provided for, for the dry season of the year by an independent culvert or channel.

During the portion of the year when the water supply to Lake Washington is such as to keep the water of that lake at a higher elevation, this deficiency is provided for by the overflow of a waste weir at the Portage lock, any excess not required at Puget Sound being disposed of by a similar waste weir at the outer lock.

It is estimated that the average time required to fill or to supply the prism of either of the locks at Puget Sound will be ten minutes, and that ten minutes more will be consumed in moving a vessel in and out of the locks and in opening and shutting the gates, or that, for one complete lockage, either up or down, twenty minutes will be required.

The greatest number of vessels can be passed through either of the locks in a given time by passing them alternately up and down, and under such conditions, one lockful of water only will be used in passing one vessel each way.

Under the assumption as to the time of operating the outer lock, one vessel can be passed each way through the lock in forty minutes, or thirty-six vessels each way in twenty-four hours, and thirty-six lockfuls of water will be required for the work.

The following are the areas of the respective drainage basins, and of the water surfaces which they contain:

	Area of drainage basin.	Area of water surface.
	Sq. miles.	*Sq. miles.*
Lake Samamish	102	8.0
Samamish River	109	0.3
Lake Washington	182	38.9
Lake Union	6	1.5
Total	399	48.7

The cubic capacity, between gates, of the prism of either of the locks at Puget Sound, with an average lift of 14.4 feet, is 302,400 cubic feet. As the inflow to Lake Washington during the dry season of the year is in excess of the evaporation from its surface, any draft upon the waters of that lake for lockage at Puget Sound will be in part supplied by the excess, which will be diverted from the outlet at Black River.

Assuming, however, that there is no excess to supply this draft in part, but that all of the lockage water required tends to the lowering of Lake Washington, it is found that the level of that lake will be reduced by continuous lockages during the three dry months to the extent of a little over nine-tenths of a foot. Any leakage of water at the outer lock in excess of that required for lockage and the water necessary to operate the hydraulic motors at the lock, will increase the abatement. The amount of the leakage will depend upon the construction of the gates and valves, and by care in construction can be reduced to a small amount. The water required for power will be but a small fraction of the whole, and, until data for closer computation are afforded, may be ignored as immaterial in these approximations.

Assuming that the supply during the dry season will be furnished by the entire water area of Lakes Samamish and Washington and Samamish River, covering an area of 47.2 square miles as against 38.9 square miles of Lake Washington alone, the abatement due to the lockages during the three dry months will be three-fourths of a foot.

In the computations upon which the above statements are based, no account is taken of the small amount of rainfall during the three dry months, which if considered would decrease the computed abatement of the lakes.

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Continuous and uninterrupted operation of one of the locks on Puget Sound during an entire year will admit of 13,140 double lockages. A rainfall of 4.35 inches during the entire year drained from the basins of Lakes Washington and Samamish and of Samamish River, having a combined area of 393 square miles, will supply all the water required for the total annual lockage.

The average current through the canal due to the water required for lockage will be less than three one-hundredths of a mile per hour.

Cedar River, entering Black River about a half a mile below the outlet of Lake Washington, is subject to annual floods, due chiefly to the melting of the snow at the head waters of that river in the Cascade Mountains. At infrequent intervals in the past, this flood has reached large proportions, overflowing for a short time the land adjacent to the outlet. The ordinary annual floods, however, do not overflow the banks of the river.

During the height of these floods the direction of the current in Black River between Lake Washington and the mouth of Cedar River is reversed, and a large volume of water is then emptied into the lake, causing a very marked elevation of its level.

In former years the Duwamish River was more obstructed by bars and drift than at present, and the low bottom lands in that valley were covered with a dense growth of brush, which impeded the flow of water when those lands were submerged. The subsequent removal of obstructions in the river and the clearing of the low lands, permitting a much freer discharge toward Puget Sound, has so materially checked this reflux into the lake that the fluctuations of its level have been reduced from about 7 feet, reported as the maximum of former years, to less than 3 feet in recent years. It is probable that the last noted rise in the level of the water may be somewhat exceeded, as there has not been in recent years any extraordinary flood corresponding to that causing this former maximum rise.

The construction of the canal will open an outlet that will carry off to Puget Sound, through Lake Union and Salmon Bay, such a volume of water that will tend to further reduce the range of fluctuation in Lake Washington, without inducing a current that will interfere with the traffic on the canal or endanger its banks. The effect in that direction of the relatively small discharge through the existing small canal at the Portage has been manifest during the past few years.

It appears probable, therefore, that upon the recurrence of one of the greater floods after the construction of the canal, the rise, by reason of the freer outlet offered to the water, will not be so excessive as to interfere with the navigation of the canal.

The fall in Black River is such as to admit of the enlargement of its channel by deepening the rock bottom so as to permit a larger outflow from Cedar River to the Duwamish River.

The following table shows the fall of the surface of the water in Black River, at the time of survey, over a distance of 8,300 feet, from the lake:

	Distance from Lake Washington.	Interval.	Elevation above datum.	Fall.	Rate of fall; foot per hundred.
	Feet.	*Feet.*	*Feet.*	*Feet.*	
Lake Washington	0	.....	33.1	.....	.....
Head of Cedar Rapid	3,100	3,100	33.1	0.0	0.00
Mouth of Cedar Rapid	3,600	500	32.5	0.6	0.12
Foot of Cedar Rapid	4,500	900	30.8	1.7	0.19
Station 45	5,700	1,200	29.5	1.3	0.11
County road bridge	6,600	900	28.5	1.0	0.11
Railroad bridge	8,300	1,700	26.7	1.8	0.11

In the early consideration of the canal project the equalization of the levels of Lakes Washington and Union was considered: First, by lowering the level of Lake Washington to that of Lake Union; second, by raising the level of Lake Union to that of Lake Washington; and third, by bringing the levels of both lakes to one intermediate between the two.

All of these schemes dispense with the need of a lock at the Portage.

In those wherein the water of Lake Union is raised, the amount of excavation in the canal prism between that lake and the outer locks will be decreased, but the cost of the locks will be increased by reason of the greater lift required to be given to them.

The structures on the lake front are built to the present water level, and should the water materially be raised, extensive and costly changes would be required in such structures.

The raised lake level being carried through to the outer locks at Puget Sound, the lower parts of the town of Ballard and other low land adjacent to Salmon Bay,

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which, under the projects adopted in the estimates, are submerged, would be flooded to a greater depth, and the area of submerged land largely increased; to such an extent, indeed, as to increase the measure of damages largely in excess of that of any advantages that might be derived from such a scheme.

The lowering of the level of Lake Washington to any considerable extent would check the outflow through Black River, or stop it altogether, and draw from Cedar River, especially during its flood, a larger part of its waters. In that case an outlet for the entire water of the drainage basins of the lakes, together with a part of the waters of Cedar River largely in excess of that now emptying into the lake, would have to be provided for through the canal. This would materially interfere with the navigation of the canal, not only during the time of floods, but for some time thereafter, until the accumulated waters had passed off.

Under such a scheme, the amount of the excavation at the Portage would be very materially increased.

It is very doubtful whether it is practicable, to lower, through a canal of the standard cross-section to be cut through at the Portage, the surface of the water in Lake Washington, containing an area of 38.9 square miles, to the level of Lake Union, and that of Lake Samamish and Samamish River, containing an area of 8.3 square miles attendant upon it.

The want of reliable data of the amount of rainfall and evaporation in this district; of the duration and rate of fall during the heaviest precipitation; of the retardation of such precipitation on its way to the lakes, and of the volume of discharge through the channels of Samamish and Black rivers, under various conditions of elevation of water surface in the lakes, precludes any estimate of the effect of the inflow and outflow upon the lakes.

The ratio of the area of the larger drainage basin, containing Lakes Samamish, Washington, and the Samamish River, to the entire water area of the basin is 8.33, and to the area of Lake Washington alone 10.10. These figures represent also the ratio of rise in the lakes to depth of rainfall, if such rainfall were entirely to find its way without impediment to the lake and the outflow were at the same time prevented. As, however, the rainwater is retarded on its way to the lake and the discharge is increased as the lake rises, a rise to the extent denoted by these figures will not occur. Only in the event of a heavy rainfall continuous for a long time can there be any material rise in the surface of the water of the lakes, and upon the abatement of such excessive rainfall the lowering of the water surface will speedily follow by reason of the uninterrupted outflow. Heavy rainfalls are of rare occurrence in this country. The rainfall during the rainy season is such as to make the supply to the lakes nearly uniform.

The excavations along the lines of railroads and streets, in the small canal through the Portage and in the ditch connecting Lake Union with Salmon Bay, show that the material of the upland in the vicinity of the proposed canal is largely composed of cement gravel, and hardpan, with occasional beds of loose gravel and sand. Nowhere in the vicinity is rock exhibited except in the case of infrequent granite bowlders. The nearest rock in place is a soft sandstone ledge which crosses Lake Washington in nearly east and west direction at the south end of Mercer Island and crops out in the Duwamish Valley a short distance above the mouth of the Duwamish River. This ledge is nowhere nearer than 6 miles to the proposed canal.

In the gap between Salmon Bay and Smiths Cove the railroad excavation which has been made, has been through loose sand and gravel easily moved. It is probable that the deeper excavation required for the canal will be largely in harder material.

In Smiths Cove and Salmon Bay the bottom is of soft mud, with a substratum of hard material. The notes of pile-driving on the line of the Seattle and Montana Railroad show the depth of soft material in Smiths Cove, except near the high-water mark, to be from 30 to 50 feet, and throughout a greater part of their line across Salmon Bay to be from 20 to 30 feet deep, the hard material being below the limit of a canal excavation.

The area of deep soft mud in Salmon Bay does not probably extend beyond the wider parts of the bay. At and below the narrows, the depth of soft mud is probably less, but as the depth of excavation for the canal is much less there, than where the deeper mud occurs, the canal excavation will probably not to any extent encroach upon the harder substratum.

The bottom of Lake Union, wherever excavations will be required, is of stiff clay. In Union Bay the ooze forming the bottom is of considerable depth. The character of the substratum is not known, but it is probably of hard material similar to that exposed in the adjacent cut through the Portage.

Elsewhere along the line of the canal between Puget Sound and Lake Washington the material, with but little exception, will probably be found to be cement gravel and hardpan.

The material of the surface in the Samamish Valley is an alluvium, the depth of

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which is unknown except at a few places in the upper part of the valley and at the abrupt bends near Lake Washington, where gravel and hard material are shown.

Lake Union has an area of 1¼ square miles. The length along its axis is 3¼ miles and the length of shore line following its principal indentations is 8¼ miles. The greatest depth of water is 60 feet, averaging 50 feet over a large extent, except at and near the head of the lake, at the Portage, where the water shoals. The shores are abrupt. This lake affords good anchorage ground.

Lake Washington has an area of 38.9 square miles, and a length, measured from north to south, of 18¼ miles. The length of the main shore line is 50 miles, and that of Mercer Island 11¼ miles. The greatest width is 4¼ miles at the head of Mercer Island, and the average width a little more than 2 miles. Excepting at the upper and lower ends of the lake, and in the few small bays along the shore, no shoals have been discovered. The shores, except at the shoals, are abrupt and fall rapidly to a depth exceeding 20 fathoms. It is reported on credible authority that in many places the depth exceeds 100 fathoms.

Lake Samamish has an area of 8 square miles and a length of 7 miles, with a length of shore line of 18 miles. The greatest width is 1¼ miles and the average a little over 1 mile. The shores are generally abrupt. A depth of from 50 to 60 feet is quite uniformly maintained. The shoals at the head and foot of the lake are of small extent.

Very respectfully, your obedient servant,

PHILIP G. EASTWICK.

Capt. THOMAS W. SYMONS,
Corps of Engineers, U. S. A.

APPENDIX—ESTIMATES OF COST.

A.—FROM PUGET SOUND TO HEAD OF SALMON BAY.

1.—*Via Shilshole Bay.*

Excavation:	Cubic yards.			
Shilshole Bay	302,000			
Pool below lock	161,000			
Lock pit	84,000			
Salmon Bay	324,000			
Total	871,000 at 50 cents			$435,500.00
Masonry lock at Salmon Bay:				
Inclosure for lock pit:				
Piles, 140, 28 feet long, 3,920 linear feet, at 8 cents		$313.60		
Driving piles, 140, at $3		420.00		
Lumber:	Feet, B. M.			
Wales, 3,400 linear feet, 8 by 8 inches	18,000			
Plank, 15,000 square feet, 3 inches	45,000			
Total	63,000 at $10.	630.00		
Iron and spikes:	Pounds.			
Drift bolts, 420, ⅞ by 20 inches	700			
Cut spikes, 6 inches	1,000			
Total	1,700 at 4 cents	68.00		
Erecting, 63,000 feet, B. M., at $10		630.00		
Embankment, spreading and packing spoil from excavation, 16,000 cubic yards, at 10 cents		1,600.00		
			$3,661.60	
Masonry:	Cubic yards.			
Main lock walls	32,000			
Guard-gate recess walls	2,000			
Upper lock-gate recess walls	1,300			
Lift wall	220			
Invert under main prism	3,700			
Invert under head bay	360			
Invert under tail bay	250			
Upper miter-sill wall	60			
Double lower miter-sill wall	140			
Stepdown	25			
Counterparts	570			
Culverts	1,600			
Total	42,225			
Classified as follows:				
Granite coping, quoins, sills, etc., 300 cubic yards, at $75		22,500.00		
Wall and culvert facing, 1,700 cubic yards, at $15		25,500.00		
Concrete, 40,225 cubic yards, at $8.50		341,912.50		
			389,912.50	

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Steel lock gates:			
Guard gate, 26 tons, at $200	$5,200.00		
Lower lock gate, 34 tons, at $200	6,800.00		
Upper lock gate, 16 tons, at $200	3,200.00		
Gate bearings, 6 tons, at $500	3,000.00		
Gate anchorages, 6 tons, at $500	3,000.00		
Gatepost anchor straps, 6 tons, at $500	3,000.00		
		$24,200.00	
Power house (including foundations and turbine wells)		10,000.00	
Machinery for operating locks and erecting same:			
Turbines, 56 inches diameter, 2, at $1,500	3,000.00		
Hydraulic gate engines, 6, at $500	3,000.00		
Hydraulic sluice gates and engines, 4, at $1,000	4,000.00		
Hydraulic capstans and engines, 6, at $1,000	6,000.00		
Hydraulic accumulator pumps, 2, at $1,500	3,000.00		
Accumulator reservoir	2,000.00		
Snubbing posts, 6, at $200	1,200.00		
Pipes and valves to connect engines with accumulator reservoir	3,000.00		
Supply and delivery pipes for turbines	5,000.00		
		30,200.00	
Dwelling house for gate-tenders		5,000.00	
Electric-light plant for lighting locks		4,000.00	
Removal of bulkheads		2,000.00	
			$463,974.10
Dam and embankment at Salmon Bay:			
Excavation for foundation, 3,000 cubic yards, at 50 cents		1,500.00	
Lumber, 270,000 feet B. M., at $10		2,700.00	
Iron and spikes, 26,000 pounds, at 4 cents		1,040.00	
Erecting timber structure, 270,000 feet, B. M., at $10		2,700.00	
Earth and puddle filling of dam:			
Puddle, 1,600 cubic yards, at 75 cents	1,200.00		
Earth (spoil from excavation), spreading and ramming 3,200 cubic yards, at 20 cents	640.00		
		1,840.00	
Earth embankment: To connect dam with lock walls and shore (spoil from excavation), spreading and ramming 40,000 cubic yards, at 15c		6,000.00	
Stone revetment: To protect outer slope of dam, 3,200 cubic yards, at $2		6,400.00	
			22,180.00
			926,654.10
Engineering and contingencies, 10 per cent			92,665.41
Total			1,019,319.51

2. Via Smiths Cove.

	Cubic yards.		
Excavation:			
Smiths Cove	223,000		
Pool below lock	178,000		
Lock pit	84,000		
Boulevard cut	963,000		
Salmon Bay	249,000		
Total	1,697,000, at 50 cents		$848,500.00
Masonry lock at Smiths Cove: Estimated to cost the same as that at Salmon Bay			463,974.10
Dam and embankment at the narrows in Salmon Bay			25,000.00
Wagon-road bridge, pier, and abutments, including electric motor to operate same			8,000.00
Land damages and right of way:			
21 acres at $1,000		$21,000.00	
17 acres at $3,000		51,000.00	
			72,000.00
			1,422,474.10
Engineering and contingencies, 10 per cent			142,247.41
Total			1,564,721.51

B.—FROM HEAD OF SALMON BAY TO LAKE UNION.

	Cubic yards.		
Excavation:			
Fremont Cut	701,000		
Shoal, foot of Lake Union	13,000		
Total	714,000, at 50 cents		$357,000
Wagon-road bridges, piers, and abutments, including electric motors to operate same:			
At Ross, 1 bridge		$8,000	
At Fremont, 1 bridge		8,000	
Electric wire line to connect motors at bridges with dynamo at lock, 4 miles, at $500		2,000	
			18,000

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Land damages and right of way, 20 acres at $3,000			$60,000
Removal of sawmill, dwellings, and stores at Fremont			25,000
			460,000
Engineering and contingencies, 10 per cent			46,000
Total			506,000

C.—FROM LAKE UNION TO LAKE WASHINGTON.

Excavation:	Cubic yards.		
Shoal, head of Lake Union	135,000		
Lock pit	67,000		
Portage cut	537,000		
Shoal, Union Bay	385,000		
Total	1,124,000, at 50 cents		$562,000
Masonry lock at Portage:			
Inclosure for lock pit, embankment (spoil from excavation), spreading, and packing, 14,000 cubic yards, at 10 cents		$1,400.00	
Masonry:	Cubic yards.		
Guard-gate recess walls	1,400		
Main lock walls	24,000		
Upper lock-gate recess walls	1,400		
Lift wall	115		
Invert under main prism	3,700		
Invert under head bay	360		
Invert under tail bay	250		
Upper miter-sill wall	60		
Double lower miter-sill wall	140		
Stepdown	20		
Counterparts	340		
Culverts	1,600		
Total	33,385		
Classified as follows:			
Granite coping, quoins, sills, etc., 300 cubic yards, at $75	$22,500.00		
Wall and culvert facing, 1,500 cubic yards, at $15	22,500.00		
Concrete, 31,585 cubic yards, at $8.50	268,472.50		
		313,472.50	
Steel lock gates:			
Guard gate, 16 tons, at $200	3,200.00		
Lower lock gate, 13 tons, at $200	2,600.00		
Upper lock gate, 18 tons, at $200	3,600.00		
Gate bearings, 6 tons, at $500	3,000.00		
Gate anchorages, 6 tons, at $500	3,000.00		
Gatepost anchor straps, 6 tons, at $500	3,000.00		
		18,400.00	
Power house, including foundations and turbine wells		10,000.00	
Machinery for operating locks and erecting same:			
Turbines, 56 inches diameter, 2, at $1,500	3,000.00		
Hydraulic gate engines, 6, at $500	3,000.00		
Hydraulic sluice gates and engines, 4, at $1,000	4,000.00		
Hydraulic capstans and engines, 6, at $1,000	6,000.00		
Hydraulic accumulator pumps, 2, at $1,500	3,000.00		
Accumulating reservoir	2,000.00		
Snubbing posts, 6, at $200	1,200.00		
Pipes and valves to connect engines with accumulator reservoir	3,000.00		
Supply and delivery pipes for turbines	5,000.00		
		30,200.00	
Dwelling house for gate-tenders		5,000.00	
Electric-light plant for lighting locks		4,000.00	
Removal of bulkheads		2,000.00	
			384,472.50
Dam and embankment at Portage:			
Excavation for foundation, 3,000 cubic yards, at 50 cents		1,500.00	
Lumber, 170,000 feet B. M., at $10		1,700.00	
Iron and spikes, 15,000 pounds, at 4 cents		600.00	
Erecting timber structure, 170,000 feet, B. M., at $10		1,700.00	
Earth and puddle filling of dam:			
Puddle, 800 cubic yards, at 75c	600.00		
Earth (spoil from excavation) spreading and ramming 1,600 cubic yards at 20c	320.00		
		920.00	
Earth embankment to connect dam with lock walls and shore (spoil from excavation) spreading and ramming 10,000 cubic yards at 15c		1,500.00	
Stone revetment to protect outer slope of dam, 2,000 cubic yards at $2		4,000.00	
			11,920.00

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Sluice gate at Portage to supply water for outer lock during the dry season		$5,000.00
Wagon-road bridges, piers, and abutments, including electric motors to operate same:		
At Latona, one bridge	$8,000.00	
At The Portage, one bridge	12,500.00	
Electric-wire line to connect motors at bridges with dynamo at lock, 1½ miles, at $500	750.00	
		21,250.00
Land damages and right of way, 12 acres, at $500		6,000.00
Extinguishment of existing canal rights		30,000.00
		1,020,642.50
Engineering and contingencies, 10 per cent		102,064.25
Total		1,122,706.75

D.—FROM LAKE WASHINGTON TO LAKE SAMAMISH.

	Cubic yards.	
Excavation of canal prism:		
Shoal, head of Lake Washington	455,000	
Lock pit	50,000	
Samamish Valley cut	6,770,000	
Total	7,275,000 at 50 cents	$3,637,500.00
Excavation of drainage ditches at sides of canal, 504,000 cubic yards at 50 cents		252,000.00
Masonry lock at Lake Washington, complete		410,000.00
Dam and embankment at Lake Washington		15,000.00
Wagon-road bridges, piers, abutments and approaches, 9 bridges at $8,000		72,000.00
Railroad bridges, piers and abutments, 4 bridges at $10,000		40,000.00
Changes and readjustment of Seattle, Lake Shore and Eastern Railway		10,000.00
Land damages and right of way, 428 acres at $100		42,800.00
		4,479,300.00
Engineering and contingencies, 10 per cent		447,930.00
Total		4,927,230.00

Change of railway locations at and near Salmon Bay.

ESTIMATE OF COST.

Excavation 32,000 cubic yards, at 30 cents		$9,600.00
Embankments (spoil from excavation) spreading 104,000 cubic yards, at 15 cents		15,600.00
Double-track trestle, 1,300 linear feet, at $9		11,700.00
Single-track trestle, 1,100 linear feet, at $6		6,600.00
Drawbridge for combined rail and wagon roads, including piers, abutments, and electric motor to operate same		15,000.00
Raising and readjusting old track two-thirds of a mile, at $400		266.67
Removing abandoned track 3½ miles, at $400		1,250.00
New material for excess of new location over old location, new rails, 60 pounds per yard, 19 tons, at $40	$760.00	
Fish-plates, 2,200 pounds, at 4 cents	88.00	
Fish-plate bolts, 300 pounds, at 5 cents	15.00	
Cross-ties, 9,000, at 25 cents	2,250.00	
Railroad spikes, 18,000 pounds, at 4 cents	720.00	
		3,833.00
Laying new track, 3½ miles at $800		2,666.67
Ballasting, 8,200 cubic yards, at 75 cents		6,150.00
Right of way, 6 acres, at $1,500		9,000.00
		81,666.34
Engineering and contingencies, 10 per cent		8,166.63
Total		89,832.97

COMMUNICATION OF MR. WESLEY WILSON, MANAGER SEATTLE COAL AND IRON COMPANY.

SEATTLE, WASH., *March 24, 1891.*

GENTLEMEN: Having been advised of your being in this city for the purpose of looking over the ground of the proposed route of said canal, and obtaining such information as to the necessity of, and needs to, commerce and the probable advantage to be derived therefrom, I would, on behalf of the Seattle Coal and Iron Company, beg to submit the following for your information:

Our mines are located at Gilman, King County, Wash., about 3 miles distant from the head of Samamish Lake.

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Our capacity to produce coal eighteen months ago, was 150 tons per day. Our capacity to-day is 600 tons per day, a large portion of which, say 350 to 400 tons per day, we find a market for in San Francisco, Cal., and other towns and cities on the Pacific Coast.

South of us we have also sent some of our coal to Honolulu. We expect within the next year or two to be able to increase our output to 2,000 tons or more per day, most of which will require to be shipped by water to points of consumption.

We find ourselves very much handicapped by the enormous expenses of maintaining bunkers for the loading of coal into sea-going vessels in the salt water of Puget Sound, by reason of the ravages of the teredo on the piles required to support the bunkers necessary to transfer said coal from the railroad cars to the vessels. So bad are they that we have had piles entirely destroyed that were not in use over four months, and we have found the average life of an unprotected pile to be not over nine months and the cost of such piles to be about $5 each when in place.

The cost of bunkers erected on such a foundation as mentioned is very expensive indeed, and when the foundation gives way from causes stated it is almost an impossibility to replace the same, on account of there being no way to get new piles driven without first virtually destroying the upper structure.

Our present facilities we regard as but temporary and contain no storage compartments, simply enabling us to dump coal from cars to ship, one car at a time, which process is slow and expensive and causes much detention to vessels, thereby adding to the cost of transportation on account of such detention. We have expended about $65,000 toward the erection of permanent facilities for holding coal in bunkers, and it will cost us at least $35,000 more to complete same. These when completed will enable us to give quick dispatch to vessels, which will enable us to secure lower rates for transportation, from which all our customers will derive substantial benefit in the decreased cost of fuel. Could we get vessels into fresh water and erect extensive bunkers there, which we would do, the cost of their maintenance would be merely nominal, which would enable us to still further reduce the cost of fuel to manufacturers and other consumers, which would assist largely in building up manufacturing industries on the Pacific Coast as against foreign competition in manufactured products, and by reducing the cost of fuel from our mines to the Pacific Coast would shut out very much of the foreign coals that are being imported to San Francisco and other points on the coast, thereby enriching our own citizens by keeping the money paid for same, instead of impoverishing them by having to send the money to foreign countries to pay for same.

In my judgment the benefits to be derived from being able to get the largest sea-going vessels into fresh water through the proposed canal, would in a very few years be simply almost incalculable.

You will please bear in mind that I have spoken of one industry (coal) only, which is only one of many. I firmly believe that all the foreign shipments of coal going from the Pacific Northwest would go via this projected waterway in the near future.

For information as to the tonnage of other large producing companies that would be immediately tributary to this route, I would respectfully refer you to Jno. L. Howard, esq., manager of the Oregon Improvement Company, and P. B. Cornwall, esq., president Black Diamond Coal Mining Company, both of San Francisco, and to J. L. Coleman, esq., secretary of the Cedar River Coal Company, of this city: All of which has been hastily written and respectfully submitted in the hope that it may aid you in forming your conclusions as to the pressing need of the early completion of this almost indispensable outlet for traffic.

I beg to remain, gentlemen, with kind regards, your most obedient

WESLEY WILSON, *Manager.*

Col. G. H. MENDELL,
Maj. THOMAS H. HANDBURY,
Capt. THOMAS W. SYMONS,
Chairmen and members of the Board of U. S. Engineers in the matter of ship canal from Puget Sound to Lake Samamish, King County, Wash.

LETTER OF MR. J. FURTH, PRESIDENT CHAMBER OF COMMERCE, SEATTLE, WASH.

CHAMBER OF COMMERCE,
Seattle, Wash., June 23, 1891.

DEAR SIR: I have the honor to submit herewith, for your perusal, statement which has been prepared by a special committee of this association bearing upon the necessity and benefits to be derived from a ship canal connecting the waters of

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Puget Sound with Lake Washington. After reading, we would be pleased to have you forward it, with other matter which you are having prepared bearing upon the subject, to the War Department.

This statement has been compiled as suggested by you when here.

Yours respectfully,

J. FURTH, *President.*

Col. G. H. MENDELL.

STATEMENT OF COMMITTEE OF CHAMBER OF COMMERCE, SEATTLE, WASHINGTON.

The survey authorized by Congress of the proposed ship canal to connect Lake Washington with Puget Sound at Seattle having been completed, the attention of the honorable Secretary of War is respectfully invited to the following, presenting some of the reasons why this canal should be promptly constructed: The city of Seattle is situated almost in the center of the Puget Sound region and has a frontage on salt water of more than 6 miles. Lake Washington lies abreast of the city to the eastward parallel with the Sound, and stretches north and south 25 miles. Deeply embayed by a cordon of mountains, its surface is always smooth and safe; its shores are bold but not rocky; its waters of ample depth, soundings showing in places 100 fathoms. Its width near its central section is 4 miles and the average nearly 3, affording ample room for handling vessels of the largest size. The absence of tides and currents renders its waters always tranquil and of even stage, and preserves its banks without washing. Its outlet by an easy channel, enters the sound almost within the present city limits.

Bordered with fertile lands, backed with inexhaustible forests of finest timber, and immense fields of coal, iron, and the precious minerals, the situation of this lake has not failed to attract the attention of every one versed in the ways of business or commerce who has visited the region.

Another such body of fresh water lying within 2 miles of a noble ocean roadstead with which it may easily be joined, capable of being converted into anchorage ground for the fleets of the world, does not exist elsewhere; it would seem to have been provided by nature as a complement to our harbor system which it will make perfect in its every feature.

Puget Sound having been for many years marked as the seat of coming great commercial expansion has become within the last decade the focus of enterprise looking to the realization of its future—four great transcontinental railway lines for the termini of their systems. Already two of them are establishing ocean steamship lines to Asia and the oriental islands.

From all parts of the world come fleets of vessels to this inland sea to compete for the cargoes which lie close at hand or arrive as freights of railways spanning the continent. The tide of progress in trade and commerce is so rapid as to run ahead of the facilities provided, and such is likely to be the case for years to come. The eyes of the industrial world are set this way.

A cursory glance at the resources of the State shows good reasons for faith in its future.

The wheat yield of 1890 was about 20,000,000 bushels; that for the current year is estimated at over 25,000,000 bushels. The capacity of the natural wheat fields of the State is conservatively placed at 200,000,000 bushels per year. Oats, barley, hay, fruits of all kinds, and every farm crop reward the husbandman with prodigious returns.

The lumber cut of the State for 1890 was 1,222,830,042 feet, an increase of 538,647,042 feet over the preceding year; nearly 100 per cent. This does not include the lumber cut into laths, pickets, etc., estimated at 174,186,800 feet.

The coal output of the State for 1890 was 1,349,773 tons, an increase of 438,246 tons, or about 50 per cent for the year.

The coal measures are practically limitless in extent, and the business of shipping coal is in its infancy. The amount of coal mined hereafter, will be limited only by the demand for it.

Iron ores of the best quality, fit for steel making, cover an immense field. Works for its manufacture are in course of construction at several points.

The precious metals are distributed over a wide area and promise enormous development of wealth. Gold, silver, lead, copper, tin, asbestos, graphite, limestone, marble, granite, and sandstone are to be added to iron and coal. All these combined furnish an opulence of mineral resources rarely encountered in a single field.

A State possessing unrivaled agricultural advantages, and having superadded to these, such incomparable wealth in timber and minerals, can not fail to develop manufacturing interests on a gigantic scale. Such development is already entered upon.

With the completion of the railroads now speeding to their terminals at this point, the State will have an enjoyment of transportation lines greater and more perfect

than any one State has hitherto equipped. She will be prepared to handle with utmost dispatch the traffic which throngs at her gates.

Great as the outlook for domestic trade may appear, it does not exceed the just scope for foreign commerce.

The trade of China alone is conservatively estimated at $150,000,000 annually. That country has but just begun to make use of American products in large amounts. Every year she adds to her demands for timber, flour, and manufactured goods. But the special field for expansion of trade is in manufactures of iron and steel.

A country without railways, her manifest destiny is to develop on a scale demanding enormous consumption of iron and steel, these modern means of improving civilization. Asiatic Russia has already entered upon this work in her possessions north of China.

Australia is opening wide doors to American trade, and cargoes to her ports multiply yearly in astonishing ratio.

Japan and the coast countries are adding steadily to the volume of commercial business with our people. In South American countries, several of them possessing immense timberless savannas, the lumber of Puget Sound finds a profitable and growing market. This trade is apparently only in its incipiency, and is being augmented constantly.

Machinery, domestic utensils, manufactures of iron and wood, every product of our workshops, whether made on the Pacific or coming by rail from eastern centers, are now to be added to the list of articles for trade with the South American States, a people rich in resources but possessing meager manufactures. Return cargoes of sugars, coffee, spices, precious woods, dyestuffs, gums, tropical fruits, and nitrates will seek these waters for their distribution by the railways to inland points.

The Nicaragua Canal, a necessity of the times and certain now of speedy construction, will open the door to a vast tide of commerce from the Atlantic seaboard, from ports both of the United States and South America. It will reduce by one-half the distance to European ports and bring a mighty current of traffic from that country.

Thus from Asia, the greater island of the southern ocean, the rich East India ports, the immense stretch of the Atlantic seaboard, the fruitful lands of western Europe, a rising volume of commercial business is sweeping this way and must be received and cared for in Puget Sound or else surrendered to our active and determined competitors to the north of us.

It is not too much to assert that a commercial expansion equal to that now existing at the port of New York is impending for these waters. A far greater shore line than that port has will be essential for the proper accommodation of the docks and wharves required here for the reason that nearly the entire shipping of the Pacific coast must find harbor facilities at a few ports embracing Puget Sound, San Francisco, and the mouth of the Columbia River, whereas many good harbors exist on the Atlantic seaboard within easy radius of New York.

Australia and all of Oceanica lie nearer to Puget Sound than to England on the Pacific side; the Malay peninsula makes the halfway point. Japan and all northern Asia are thousands of miles nearer to us than to London. Our commerce is now within less than three weeks of the coast of China. Statistics show that New York by way of Puget Sound is 1,400 miles nearer to Canton than is Liverpool, and about 4,000 miles nearer Shanghai.

Puget Sound has also the advantage in distance to Asiatic points over San Francisco. The following table of distances, culled from Prof. Ruffer's interesting report upon the State of Washington, presents significant data upon the nearness of Puget Sound to points of commercial vantage ground:

	Miles.
Seattle to—	
Mouth of Amoor River	3,900
Vladivostock	4,700
Shanghai	5,750
Canton	6,500
Singapore	8,100
Southwest point of Australia	9,550
San Francisco to—	
Vladivostock	5,200
Shanghai	6,100
Canton	6,800
Singapore	8,400
Southwest point of Australia	9,500
Calcutta	10,200
Liverpool to—	
Mouth of Amoor River	13,550
Vladivostock	12,700
Shanghai	11,750

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	Miles.
Liverpool to—	
Canton	10,900
Southwest point of Australia	10,750
Singapore	9,300
Calcutta	8,700
New York to—	
Canton via Puget Sound	9,500
Shanghai via Puget Sound	8,000

It is well known that the carrying trade of the world is being transferred by rapid stages from wooden bottoms to hulls of iron and steel. So fast is the transfer being made that wooden-ship yards are constantly going out of commission. Vessels of war are no longer thought of as made of wood. Iron and steel rule the shipping of all seas.

It is also well known that iron and steel bottoms are subjected in salt water to marine growths which adhere to them and greatly impair the efficiency of the vessels. The speed of an iron ship is often reduced one-half by the presence of grass and barnacles adhering to the bottom, and the cost of maintaining such vessels is greatly enhanced by the necessity of frequent docking to remove these accretions. Fresh water destroys marine growths and prevents their formation. Barnacles and grass, which cover a vessel's bottom in salt water to the weight of many tons, are killed by a few days in fresh water and will drop off, or may be removed easily with scrapers. So advantageous to iron shipping is an accessible body of fresh water that masters of vessels regard it as of importance next to cheap fuel at ports of arrival from sea voyages. One of the material advantages named in favor of building the Nicaragua Canal is the fact that a fresh-water lake lies midway of the canal route, and that ships will pass through it in their progress from ocean to ocean, and may avail themselves of its waters for freeing their bottoms from marine accretions. Puget Sound possesses cheap fuel for coaling vessels; it has abundant cargoes; a canal to Lake Washington will add immensely to its present advantages.

The most ample and perfect facilities are of paramount importance to the great transcontinental railway lines which converge here. If these railways are important and necessary from a military point of view, if they tend to bind together and unify the distant sections of the Republic, and hence possess national importance beyond their value as transportation lines, then certainly they should have complete terminals to enable them the more efficiently to aid in the work of developing and building up the material resources of the country. In this connection the fact is not to be lost sight of that our neighbor, the Dominion of Canada, spares no expense and loses no opportunity to make perfect her transcontinental railway facilities, and that she is preparing to contest with us most strenuously for the ocean carrying trade.

With a ship canal joining the waters of Lake Washington with Puget Sound our advantages for shipping would be ideal in character and superior to those of all other ports on the Pacific coast. Indeed this unique advantage would make Seattle preëminent in facilities for shipping amongst the ports of the world. A vessel could come to her dock in fresh water undisturbed by tidal flow, and while discharging cargo her bottom would be cleared of its burden of barnacles and grass without the delay and expense of docking. She would thus save two or three days' time as well as considerable expense. The demurrage alone thus avoided would aggregate for the tonnage entering the port a large sum each year.

But a desideratum of the most practical importance is the increase of shore line available for wharves and docks which this improvement involves. Lake Washington would add more than 50 miles to the dock front of Seattle, increasing her harbor capacity tenfold and giving here transcendant advantages in this regard.

The maintenance of wharves and docks in the salt water of the sound is now very expensive by reason of the ravages of the teredo, which often destroys piling within a single year after driving, so that the wharf goes down with loss of its entire stores, and sometimes with loss of life. In the fresh water of the lake, piling will last practically without limit. The saving in the cost of maintaining docks and wharves alone would far more than repay the cost of constructing the canal.

Manufactures already seek Lake Washington; its fresh water for making steam, its nearness to the coal and iron mines, its cheap wharf facilities, and the ample room which it affords, counterbalancing the expense of rehandling the manufactured product when shipped foreign. Three railway lines, the Northern Pacific, the Great Northern, and the Seattle, Lake Shore and Eastern, have already established themselves on the lake and its outlet, recognizing its great commercial importance. The Northern Pacific Company has built a road along the whole eastern front of the lake. But notwithstanding the railway facilities, many industrial enterprises are precluded from locating here while the canal is not built, such as flouring mills,

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grain elevators and warehouses, lumber mills, etc., whose products are shipped largely by vessel.

Every foot of the shore line of this lake would come into practical use for the accommodation of shipping and manufactures, were the canal built.

The timber of the coast and bordering upon the rivers near the coast has been nearly used up, so that the vast forests of the interior must now be resorted to for supplying the demand. Twenty million acres of these forests must be reached by rail. An enormous timber product will come to Lake Washington and be manufactured and shipped hence, when the proposed connection with the Sound is completed.

Wheat warehouses, elevators, and flouring mills, for handling and manufacturing the immense yield of grain which the wheat fields of eastern Washington produce in amounts largely increasing every year, await establishment here only until such time as the canal to the Sound is completed.

A comprehensive plant for the reduction of iron ores and the manufacture of steel is in course of construction at Kirkland, a manufacturing suburb of Seattle, on the east side of Lake Washington. This blast furnace will use the magnetic ore from the Denny iron mines, situated about 30 miles east of the lake. The ore (referred to in another place) compares favorably with the magnetic ores of Lake Superior, hitherto ranking as the best upon the continent. The railway which will bring in this ore will also bring superior coking coal from the Niblock coal mine, located only 20 miles east of Kirkland. This will be coked and used in the manufactories on the banks of the lake.

Smelting works for ores of the precious metals will also be established on the lake where coke will be convenient, the ores coming by rail on a down grade from the mines.

A great city placed at the focal point where the commercial tides of two continents converge will beget an infinite number and variety of important industries, while the wondrous progress of the age will in its swift march bring forth others not yet known to the inventor. The unmistakable signs of the time point to this as a great manufacturing and industrial center.

Congress is recreating the Navy of the United States, but as yet the work is hardly begun. The position of Puget Sound demands here a large fleet. A Government dry dock has been provided for already, to be followed probably with a fully equipped navy-yard.

A ship canal into Lake Washington would afford in these waters the most complete advantages for naval vessels of any in the United States. If there was a military reason for endowing the Pacific railways and making them national highways, there is a still stronger military reason for Government owning the proposed canal and removing it from the control of private persons or corporations, since this improvement would be the link connecting the military railway with a terminal position of great strength available for naval protection.

While commercial development would be greatly stimulated and the establisment of manufactures accelerated by reason of the proposed improvement, the expense of wharfage and dockage, the handling of cargoes, the lading of vessels and storing of freights, in fact the cost of all the various charges on shipping at the port, of whatever nature, would be materially lessened, as a result of the ample extent of water front and ship anchorage provided for the city of Seattle.

Not only for economic reasons, but for reasons of prudence and sound national policy, the Government should provide, control, and manage this enterprise, shown to be of prime national importance.

The cost of the work is but a bagatelle in view of the interests to be subserved, and the results certain of attainment.

THOMAS BURKE,
J. FURTH,
E. W. CLARKE,
C. M. SHEAFE,
Chamber of Commerce Committee.

COMMUNICATION OF MR. J. W. DODGE, SECRETARY CHAMBER OF COMMERCE, SEATTLE, WASHINGTON.

THE CHAMBER OF COMMERCE,
Seattle, Washington, June 30, 1891.

DEAR SIR: Since reading and forwarding to you statement compiled by special committee of the chamber bearing upon the Lake Washington canal project, it has occurred to me that some points of importance in determining the size of the canal, character of locks, etc., were not mentioned. I therefore take the liberty of calling your attention to a few points that present themselves to my mind. The first, is the probable amount of coal tonnage. At the present time, there are five mines tributary to Lake Washington in operation; one developed, but not yet producing, and

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three in process of development. The names and daily capacity of the mines in operation, also the prospective capacity of each in the event of proper shipping facilities being afforded, are below given:

Name.	Present daily capacity.	Prospective daily capacity.
Gilman	600	2,000
Newcastle	1,000	2,000
Cedar River	200	500
Black Diamond	1,000	2,000
Franklin	500	1,000
Total	3,300	7,500

The next feature that occurs is the amount of lumber that would be shipped from Lake Washington were facilities afforded.

There has been during the past year cut and floated on Lake Washington, for the use of mills located on Lakes Union and Washington, about 9,000,000 feet of logs, and there is being handled at the present time about 300,000 per working day. This would be but a small portion, comparatively speaking, of the amount that would be handled were there direct shipping facilities from the lake. It is estimated that there are 16,000,000,000 feet of timber now standing in King County. Over one-half of this, and an equal amount in Snohomish County, is directly tributary to Lake Washington. Western Washington is destined to be a heavy producer of metals, both base and precious, and while it would be impossible to estimate the extent of shipments of the various classes it is but proper that attention should be called to the fact that extensive iron and steel works are now under construction; that a company has recently been formed for the purpose of smelting and refining precious metals, the extent and value of which are each day becoming more apparent.

The size and character of vessels which would frequent these waters in case the canal was constructed would also be a matter of importance to you in determining the size of locks and depth and width of basins. From the best information I am able to gather from vessel owners, it is apparent that there is a decided tendency to increase the tonnage capacity. Bearing in mind that the freight would consist chiefly of coal, coke, grain, lumber, furniture, machinery, iron products and other metals, the canal and locks should be capable of handling vessels of large capacity. Vessel owners here are of the opinion that the prevailing type will be of about the following average: 2,000 tons register, 350 feet in length, drawing 26½ feet water, 43 feet beam. Grain merchants seem to think that vessels similar to the *John R. Kelly*, which has net tonnage of 2254, and length of 256.9 feet, breadth of 45 feet and depth 27.8 feet, will represent the style of grain carrier. The fact that the new steel barges, which are now in use to a limited extent on the Great Lakes, will also soon be plying these waters, should also be borne in mind. No estimate has been made of the probable amount of grain shipments, for the reason that our experience in this line has been for so limited a period (the first elevator shipments from this port being made in August, last year) that we can not with any degree of accuracy estimate it. The elevator, which was completed and commenced business last August, has handled under adverse circumstances about 1,000,000 bushels during the past ten months, all received from one line of road. With the completion of the great Northern and Union Pacific and the extension of other roads now in prospect, which will pass through large areas of grain-producing land, the amount of tonnage that can and will be handled under favorable conditions is beyond estimate. Bulletins issued by the Agricultural Department show that Washington outranks all States of the Union in the yield per acre of wheat, oats, barley, and potatoes. The yield of wheat in the State for the past year has been estimated at 20,000,000 bushels. Bearing in mind the immense area of as yet uncultivated lands adapted to the production of this and kindred grains, the future of that branch of business can not be estimated.

Yours respectfully,

J. W. DODGE, *Secretary.*

Col. G. H. MENDELL.

REASONS WHY CONGRESS SHOULD CONSTRUCT A SHIP CANAL INTO LAKES UNION AND WASHINGTON, IN AID OF COMMERCE.

The advantages of a fresh-water harbor are so well known and have been so voluminously set forth by engineer officers of the Government at various times heretofore, that it is hardly necessary to give any further reasons why a fresh-water harbor should be preferred to salt water. If, therefore, it can be shown that the commerce

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of the State of Washington is so extensive that the saving in wear and tear of wharves, in deterioration of ships and vessels of all kinds, can be in a material measure reduced, or reduced to such an extent that the saving will be a great benefit not only to ship owners, but in lessening the cost of transportation and terminal charges upon the handling of the grain and other products of the country, it is hardly necessary to say that Congress will be justified in making a sufficient appropriation to build a canal into these waters. This would certainly be so if such saving would be sufficient to pay a large interest upon the cost of building such a canal. It is a well-known fact that the ravages of the teredo in the waters of Puget Sound, and, in fact, in all the waters of the Pacific Ocean, are so great as to be a tremendous tax upon commerce. All the wharves in these waters require renewal on an average of less than two years. It is safe to say that all necessary wharves could be constructed in Lake Washington for the accommodation of all the heavy commerce of the State at one-fourth the first cost that would be required to construct such wharves in the waters of Puget Sound or the Pacific Ocean; that such wharves and warehouses would last at least ten times as long, and that their maintenance in the fresh waters of the lake would be an infinitesimal sum, a small fraction of what they are in the salt water.

Again, the cost of handling ships at the wharves and the transfer of freight from rail to ship would be but a small fraction of what it is upon the sound. This would be so because of the level in the lakes being the same at all times. After the ships were once in the lake they would be absolutely safe from winds and storms.

If a canal were constructed into Lake Washington it is pretty safe to say that nearly all of the wheat and coal shipments of the State would be from the lake. This would be so because of the very small cost of handling such products for the reasons above stated, and because it is easier for all of the railroads to reach the waters of the lake than it is to reach the waters of the Sound.

As a matter of fact all of the existing railroads in the State have, either by themselves or by rail, direct contact with the shores of the lake. The amount of coal shipped now from the Sound, mainly from King and Pierce counties, is in the neighborhood of 2,000,000 tons per annum. These shipments in the near future are not unlikely to be more than doubled. The wheat product of the State for the year 1890 was nearly 30,000,000 bushels and it is safe to say that within ten years the wheat product will be nearly 100,000,000 bushels. The eastern portion of the State, when all the wheat lands are cultivated, is capable of producing about 120,000,000 bushels per annum, or say one-fourth of the present entire wheat product of the United States. The saving in cost to the farmer and the merchant in the shipment of this product by the lake instead of by salt water, would amount to an enormous sum.

In addition to the coal and wheat products the amount of lumber to be shipped from the lake would be very large.

There are also within 50 miles of the lake some of the best Bessemer iron deposits in the world. Already transportation has been nearly provided between the lakes and these deposits, and extensive works for the reduction of these ores are now being built upon the shores of the lake, and it is expected that these works and the mines will be in operation within one year from this time.

Summing up, it may be said that there is not a coal mine of any consequence in the State of Washington that can not more readily ship its product to Lake Washington than to the Sound. Neither is there any iron deposit whose product could not be more readily shipped from the lake. As a site for the establishment of the very extensive manufactures that will be required on the Pacific coast there is no point that begins to possess the advantages of Lake Washington. This is so not only by superior natural location but because of the inexhaustible supply of fresh water. If the construction of a canal were begun at once, it could not be completed before the developments in iron mining and manufacturing and in coal mining, and the wheat product, would more than justify the small expenditure required.

THE CHAMBER OF COMMERCE OF SEATTLE.
By E. O. GRAVES, *Vice-President.*
J. W. DODGE, *Secretary.*

COMMUNICATION OF MR. C. J. SMITH, GENERAL MANAGER.

PORTLAND, OREGON, *April 21, 1891.*

DEAR SIR: In relation to the business which this company would be likely to transact upon the shores of Lake Washington in case a canal was cut through from the waters of Puget Sound to Lake Washington, I would say:

This company is the owner of the Columbia and Puget Sound Railroad, a narrow-gauge road extending south and east of Seattle to the Newcastle Mine, a distance of

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21 miles, and from the junction at Renton to Franklin Mine, a distance of 34 miles from Seattle.

There is located upon this road, coal mines belonging to this company, known as the Newcastle Mine and Franklin Mine. In addition to these there is located upon the line of this railroad the Black Diamond and Cedar Mountain Mine. The entire output of these mines would find a shipping point upon Lake Washington in case a canal was cut through. The output of the mines is as follows:

		Tons.
In 1888,	Newcastle Mine	84,000
	Franklin Mine	177,000
In 1889,	Newcastle Mine	67,000
	Franklin Mine	90,000
In 1890,	Newcastle Mine	130,000
	Franklin Mine	74,000

Various causes have contributed to keeping the output of these mines very considerably below their average capacity. In 1888 there was a fire in both the Newcastle and Franklin mines, and in 1889 and 1890 the Newcastle Mine, owing to strikes, was shut down two months and the Franklin Mine four months. The estimated output of these mines, barring strikes, fires, or accidents, would be as follows:

	Tons.
Newcastle Mine	200,000
Franklin Mine	150,000
Black Diamond Mine	200,000
Cedar Mountain Mine	60,000
Total	610,000

All the output of these mines is transported over the railroad of this company and shipped from the coal bunkers of this company at Seattle, with the exception of the amount used for domestic purposes at Seattle. The amount of coal so used at Seattle would be about 75,000 tons per annum, leaving 535,000 tons for shipment. Owing to the difficulty with the teredo at Seattle, it is necessary to build these bunkers with copper-covered piles, and the shipments of the above mines are now made from coal bunkers which cost this company $168,000. Bunkers sufficient to enable this company to handle this product from fresh water at Lake Washington could be built for $50,000, and could be maintained much more cheaply than the bunkers at Seattle.

The class of vessels transporting this coal are steamers ranging from 1,000 to 2,500 tons capacity, with an average draft, loaded, of 19 feet. In addition to the coal shipped in steamers, it has been the custom of both this company and the Black Diamond Coal Company to charter sailing vessels ranging in capacity from 1,000 to 3,000 tons, with draft, loaded, of about 21 feet. This company owns or controls a fleet on the Pacific coast of about twenty steamers, ranging in capacity from 1,000 to 2,500 tons, and are now engaged in the coastwise business, with routes from Portland to Puget Sound points, and from Puget Sound points to Alaska. They have a departure of vessels averaging every four days, and in addition to the coal carried, do a very large merchandise and passenger business. It is probable that a considerable portion of this business would be done at the wharves on Lake Washington should this canal be cut through.

The Newcastle Mine of this company is located only a mile from the shores of Lake Washington, the Cedar Mountain Mine about 8 miles, the Black Diamond Mine about 16 miles, and the Franklin Mine about 18 miles. There would be a saving in distance in the carriage of coal to Lake Washington from Newcastle Mine of nearly 20 miles; from Cedar Mountain Mine of about 10 miles; from Black Diamond Mine of about 18 miles, and from Franklin Mine of about 14 over the carriage of coal to Seattle.

In addition to the mines already opened and developed, there are a number of prospects in this same region that would be opened and developed to a working output if the cost of transportation and wharfage charges were cheapened to the extent expected by the opening of service on the shores of Lake Washington.

Trusting the above information may be of use and benefit to you, I am

Yours, truly,

C. J. SMITH,
General Manager.

THOMAS W. SYMONS,
Captain, U. S. Corps of Engineers.

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T T 16.

ESTABLISHMENT OF HARBOR LINES IN OLYMPIA HARBOR, VANCOUVER HARBOR (COLUMBIA RIVER AT VANCOUVER), AND BELLINGHAM BAY (AT NEW WHATCOM AND FAIRHAVEN), WASHINGTON.

WASHINGTON, D. C., *March 1, 1892.*

SIR: On behalf of the harbor line commission of the State of Washington I have the honor very respectfully to submit herewith certain projects or preliminary plans for the improvement of the harbors of Olympia, Vancouver, and Bellingham Bay, in that State, and to ask your approval of the same.

Before any further explanation is made of these plans—herewith presented upon the accompanying maps*—and in order that the action which has heretofore been taken by the State of Washington with reference to its harbors and navigable waters may be more fully understood, I beg leave to present the following statement in relation thereto. The magnificence and unsurpassed advantages of these harbors have long been recognized by the entire civilized world. For beauty and variety, for safety, extent, convenience of access, and unlimited capacity for usefulness in the interests of commerce and navigation, they are not only far superior to any other harbors or waters of the kind on the Pacific coast between the Arctic Circle and Cape Horn, but they are not surpassed on the surface of the globe. They are surrounded by a country rich in every natural production required for the building up of great centers of wealth and population, and more particularly in those things which contribute to the growth of commerce, manufactures, and the industrial arts. A description of its resources of timber, coal, iron, mineral, agricultural, and other products would fill a volume, while its climate is of that temperate and salubrious character which conduces in the highest degree to the physical development and the industrial activity of the human family. Every transcontinental railroad across the North American continent has already secured or is striving to obtain terminal facilities on the shores of these harbors. The Canadian Pacific, the Great Northern, the Northern Pacific, and the Union Pacific Railroad companies all have terminal facilities of greater or less extent already in their possession, while every railroad company which is extending its track in the direction of the Pacific coast is hoping sooner or later to reach the waters of Puget Sound. The extraordinary growth of the commerce of Washington Territory is too well known to require at this time anything more than passing reference. The figures are to be found in the commercial statistics of the country. The people of the State of Washington, upon their admission into the Union, realized these facts and determined to utilize to the greatest possible advantage the grand commercial facilities with which nature had provided them. For this purpose they adopted a line of policy which would enable them not only to preserve, maintain, and improve these commercial facilities, but also determined to retain the possession and control of the water front in its numerous harbors, in order that they might regulate tolls and charges of all descriptions thereon, that they might make these charges reliably and permanently cheap, and keep these commercial facilities convenient and accessible to the general public for all time to come. Therefore when their constitution was framed and adopted it contained among others the following provisions:

* Not printed.

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ARTICLE XV.—HARBORS AND TIDE WATERS.

SECTION 1. The legislature shall provide for the appointment of a commission whose duty it shall be to locate and establish harbor lines in the navigable waters of all harbors, estuaries, bays, and inlets of this State, wherever such navigable waters lie within or in front of the corporate limits of any city or within one mile thereof upon either side. The State shall never give, sell, or lease to any private person, corporation, or association, any rights whatever in the waters beyond such harbor lines, nor shall any of the area lying between any harbor line and the line of ordinary high tide, and within not less than 50 feet nor more than 600 feet of such harbor line (as the commissioners shall determine), be sold or granted by the State, nor its right to control the same relinquished, but such area shall be forever reserved for landings, wharves, streets, and other conveniences of navigation and commerce.

SEC. 2. The legislature shall provide general laws for the leasing of the right to build and maintain wharves, docks, and other structures upon the areas mentioned in section one of this article, but no lease shall be made for any term longer than thirty years, or the legislature may provide by general laws for the building and maintaining upon such areas, wharves, docks, and other structures.

SEC. 3. Municipal corporations shall have the right to extend their streets over intervening tide lands to and across the area reserved as herein provided.

In order that these provisions of the constitution might be carried into effect, and in further pursuance of the same line of policy, the following laws were subsequently enacted by the State legislature:

ARTICLE XVII (OF THE CONSTITUTION).—TIDE LANDS.

SECTION 1. The State of Washington asserts its ownership to the beds and shores of all navigable waters in the State up to and including the line of ordinary high tide, in waters where the tide ebbs and flows, and up to and including the line of ordinary high water within the banks of all navigable rivers and lakes: *Provided*, That this section shall not be construed so as to debar any person from asserting his claim to vested rights in the courts of the State.

SEC. 2. The State of Washington disclaims all title in and claim to all tide, swamp, and overflowed lands patented by the United States: *Provided*, The same is not impeached for fraud.

HARBOR LINE COMMISSIONERS, STATE OF WASHINGTON.

[Laws of 1889-1890, page 239.]

AN ACT to create a board of harbor line commissioners, prescribing their duties and compensation.

Be it enacted by the legislature of the State of Washington: SECTION 1. There is hereby created a board of harbor line commissioners, to consist of five disinterested persons to be appointed by the governor.

SEC. 2. The said commissioners shall hold office until the 15th day of January, 1893. Should a vacancy or vacancies occur in said board, by resignation or otherwise, the same shall be filled by appointment by the governor.

SEC. 3. The duties of the said harbor line commissioners shall be to locate and establish harbor lines in the navigable waters of all harbors, estuaries, bays, and inlets of this State, wherever such navigable waters lie within or in front of the corporate limits of any city or within one mile thereof upon either side, and to perform all other duties provided and prescribed in article 15 of the constitution of the State of Washington, and all such other duties as the law may prescribe, and wherever and whenever said board of harbor line commissioners shall have established the lines as herein provided, in any of the navigable waters of the harbors, estuaries, bays, and inlets of this State, they shall file the plat thereof in the office of the secretary of state, and a duplicate thereof in the office of the clerk of the city or town where harbor lines shall have been located, and from and after the filing of said plat, the harbor lines established as herein designated and displayed shall be, and the same are declared to be, the harbor line of that portion of the navigable waters of this State.

SEC. 4. The board of harbor line commissioners hereby created shall begin operations as soon as may be practicable, and are hereby authorized to employ a clerk, a competent surveyor, and such assistance as may be necessary, and to purchase such material and supplies as may be necessary to carry out the full intent and purpose

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of this act, at such rates of compensation as they may deem advisable. To carry into effect the provisions of this act the sum of six thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of the tide-land funds in the State treasury not otherwise appropriated.

SEC. 5. Each of the board of harbor line commissioners shall receive five dollars ($5.00) per day for each and every day employed in the discharge of his work, and his actual traveling expenses.

SEC. 6. The board of harbor line commissioners shall examine and allow all bills incurred in the discharge of the duties provided for in this act, and upon presentation of the proper vouchers so allowed the State auditor is authorized to draw his warrant on the State treasury for the several amounts so allowed, and the State treasurer is hereby authorized to pay said warrants out of any money in the treasury appropriated for this purpose: *Provided*, That no expenses shall be incurred for the payment of which no appropriation shall have been made.

SEC. 7. The board of harbor line commissioners shall keep an itemized account of all expenses incurred, and report the same to the secretary of state.

Approved March 28, 1890.

PUBLIC WAYS ACROSS TIDE FLATS NEAR TOWNS.

[Laws, 1889-1890, page 731.]

AN ACT to establish and define public ways for water crafts across the tide flats within, in front of, and for a mile either way from, all incorporated cities and towns in the State of Washington.

Be it enacted by the legislature of the State of Washington: SECTION 1. There shall be established one or more public ways across all of the tide flats that are situated within or in front of any incorporated city or town, or within two miles either way from any incorporated city or town within the State of Washington.

SEC. 2. The public ways provided for in section one of this act shall not be less than fifty nor more than one thousand feet wide, and shall commence at the outer or deep-water end, in not less than twenty feet of water at low tide, and shall extend inland across the State's tide lands.

SEC. 3. The public ways above provided for shall be so located as to include, as near as is practicable, within their bounds, all navigable streams running through the tide flats in which they are located, and at such other places as may be necessary for the present or future convenience of commerce.

SEC. 4. All public ways established under the provisions of this act shall be well defined by posts not less than 8 inches in diameter, firmly set or driven in the ground, and of sufficient length so that they will project above the water at high tide not less than four feet, and such posts shall not be over four hundred feet apart; and all such public ways shall be correctly surveyed and connected by metes and bounds with the Government surveys, or such other permanent land marks as will make a lasting record, and a correct plat of all public ways so established shall be made, one copy of which shall be filed with the secretary of state, one copy with the commissioner of public lands of the State, one copy shall be kept in the office of the chairman of the board of harbor line commissioners, and each county shall be furnished with a correct plat of all such public ways established within its borders, and such plats shall be filed as city or town plats are filed and become a part of the county records.

SEC. 5. All the public ways that may be established under the provisions of this act are, and shall forever be, reserved from sale or lease as public ways for water crafts.

SEC. 6. Where the words "tide flat or tide lands" are used in this act they shall be construed to mean all lands over which the tide ebbs and flows, and which is bare at low tide; and where the words ordinary water crafts are used they shall be construed to mean boats, barges, and other water crafts drawing two and one-half feet and over of water.

SEC. 7. The board of harbor line commissioners are hereby authorized and instructed to carry out the provisions of this act, and they shall begin operations as soon as practicable after the passage and approval of this act; and they are hereby authorized to employ such assistance and procure such materials as may be necessary to carry out the full intent and purpose of this act, and the compensation for the same shall be such reasonable amount as said commissioners may deem advisable.

SEC. 8. All bills incurred in carrying out the provisions of this act shall be audited and paid in the same manner as is provided in the act creating the harbor line commissioners, for the payment of bills incurred by them.

Approved March 28, 1890.

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IMPROVEMENT OF HARBORS AND WATERWAYS.

[Laws 1891, page 405.]

AN ACT relating to the improvement of harbors and waterways in the State of Washington, and providing funds therefor.

Be it enacted by the legislature of the State of Washington: SECTION 1. That seventy-five (75) per cent of the proceeds derived by the State from the sale of tide lands within the limits of any incorporated city or town in the State of Washington, or within one mile on either side thereof, shall be, and the same is hereby, appropriated, and the same shall be set apart as a special fund by the State treasurer for the construction and maintenance of a system of permanent and substantial improvements in aid of commerce and navigation in and for the harbor of such city or town wherein such tide lands may be sold, and the remaining twenty-five (25) per cent shall be paid into the general tide-land fund of the State.

SEC. 2. Wherever harbor lines are now, or may hereafter be, located and established within or in front of any incorporated city or town in the State of Washington, the harbor line commission is hereby authorized and directed to approve and adopt, subject to the approval of the Secretary of War, or an advisory board created by the Secretary of War, as soon as may be practicable, such a system of harbor improvements, within the harbor line strip of each harbor wherein such lines may be located and established, as will conform as nearly as practicable to any permanent improvements constructed or under construction therein as in their judgment, and upon the available advice of competent engineers, shall be best calculated to promote the permanent commercial welfare thereof; and all funds appropriated for the purpose of harbor improvements under the foregoing section of this act, or otherwise, shall be expended under the direction, supervision, and control of the harbor line commission of the State of Washington, and the State auditor is hereby directed, upon the filing of vouchers approved by the harbor line commission, to draw warrants on the State treasurer, payable out of the several harbor-improvement funds, and the State treasurer shall pay all said warrants out of said funds.

SEC. 3. In keeping the account of this fund the State treasurer is directed to credit each harbor with the amount received for sale of tide lands, as provided in section one of this act, and debit each harbor for warrants drawn for improvements therein.

SEC. 4. All acts or parts of acts inconsistent with the provisions of this act are hereby repealed.

Approved March 10, 1891.

The declaration in the constitution that the State of Washington asserts its ownership to the "beds and shores of all navigable waters in the State up to and including the line of ordinary high tide in waters where the tide ebbs and flows, and up to and including the line of ordinary high water within the banks of all navigable rivers and lakes," is simply the statement of a fact, and in nowise adds to the actual validity of the title by which the State owns this property. That the State of Washington, by virtue of its sovereignty, and not by virtue of any act of the General Government, is the absolute owner of these tide lands and lands under the navigable waters of the State, is a principle of law now so thoroughly established by repeated decisions of the Supreme Court of the United States, that it is no longer questioned by any lawyer or layman, court or judge, who has investigated the subject. As the original thirteen colonies came into the Union the proprietors of their tide lands by virtue of the sovereignty which they had inherited from the British Crown, and which they never relinquished, and as all the States in the Union which were subsequently admitted, were admitted upon precisely the same footing as the original thirteen States, so all of the States of the Union, Washington included, are the absolute owners of the tide lands within their limits, and can make any disposition of them which may be deemed advisable or expedient, subject only to the jurisdiction of the United States over the navigable waters of these States in the interests of commerce. Each State has a perfect right to decide for itself what disposition it will make of these lands, and the

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Supreme Court of the United States has frequently decided that there is no power which can interfere with that disposition. If the State sees proper to give these lands or any interest in them to the riparian owner it has an absolute right to do so. In the case of *Hardin* v. *Jordan*, which was determined by the Supreme Court of the United States at its October term, 1890, the court said:

With regard to grants of the Government for lands bordering on tide water, it has been distinctly settled that they only extend to high-water mark, and that the title to the shore and lands under water in front of lands so granted inures to the State within which they are situated, if a State has been organized and established there. Such title to the shore and lands under water is regarded as incidental to the sovereignty of the State, a portion of the royalties belonging thereto and held in trust for the public purpose of navigation and fishery, and can not be retained or granted out to individuals by the United States. (*Pollard* v. *Hagan*, 3 How., 212; *Goodtitle* v. *Kibbe*, 9 How., 471; *Weber* v. *Harbor Commissioners*, 18 Wall., 57.) Such title being in the State, the lands are subject to State regulation and control, under the condition, however, of not interfering with the regulations which may be made by Congress with regard to public navigation and commerce. The State may even dispose of the usufruct of such lands, as is frequently done, by leasing oyster beds in them and granting fisheries in particular localities; also by the reclamation of submerged flats, and the erection of wharves and piers and other adventitious aids of commerce. Sometimes large areas so reclaimed are occupied by cities, and are put to other public or private purposes, State control and ownership therein being supreme, subject only to the paramount authority of Congress in making regulations of commerce, and in subjecting the lands to the necessities and uses of commerce. (See *Manchester* v. *Massachussetts*, 139 U. S. R., 240; *Smith* v. *Maryland*, 18 How., 71; *McCready* v. *Virginia*, 94 U. S. R., 391; *Martin* v. *Waddell*, 16 Pet., 367; *Den* v. *Jersey Co.*, 15 How., 426.)

This right of the States to regulate and control the shores of tide waters and the land under them is the same as that which is exercised by the Crown in England. In this country the same rule has been extended to our great navigable lakes, which are treated as inland seas; and also in some of the States to navigable rivers, as the Mississippi, the Missouri, the Ohio, and, in Pennsylvania, to all the permanent rivers of the State; but it depends on the law of each State to what waters and to what extent this prerogative of the State over the lands under water shall be exercised.

Space will not permit of further extracts from this decision of the court or of further notice of the large number of cases referred to in the same decision or of extracts from other decisions of a similar character. It may be sufficient to say that the same court has uniformly held that each State has the undisputed right to dispose of the tide lands within its limits as to it may seem expedient. If the State of Washington has given to the riparian owner the first privilege of purchasing tide lands, for sixty days, between his upland on the shore and deep water, it is only as an act of grace or as a concession to the exaggerated and ill-founded public sentiment in regard to riparian rights, and not because the riparian owner has any right in law or in equity either to the possession of tide lands on his front or to say what disposition shall be made of them by the State.

After the location of the harbor lines and waterways provided for by the State in the interests of commerce and navigation, extensive areas of tide land not available for those interests are to be sold in the manner provided by law. Not less than 50,000 acres are to be so disposed of by the State of Washington when these harbor lines and waterways are located. It is desirable that these tide lands should be sold as speedily as practicable, because in front of many of the principal cities of the State are large areas of tide lands valuable for building purposes, and especially for factories, machine shops, and other industrial enterprises, which are most profitably and conveniently conducted upon the water front or within easy access of navigable waters. The laws of Washington require that these harbor lines and waterways shall be located as speedily as practicable, in order that these tide lands

may be sold and made available for business purposes. The growth of most of the larger cities in Washington is now hampered and retarded because of the delay which has unavoidably been incurred in the location of these harbor lines. Beyond question the State of Washington has a perfect and absolute right to locate these harbor lines and waterways and to construct within these lines such improvements as may be deemed advisable in the interests of commerce and navigation. The object of the location of these lines is to mark out such areas to be reserved from sale as shall be considered necessary for streets, landings, wharves, and other conveniences of commerce and navigation. The areas to be reserved within these harbor lines for these purposes are from 50 to 600 feet in width, in the discretion of the harbor-line commission. They are now and are to be forever reserved as the property of the State and retained under its control, to the end that the commercial facilities thereon provided shall be made cheap and free of access to the general public, and may not fall into the hands of private persons or corporations whose exactions might prove a heavy burden upon the commerce of the State and nation.

The State has already appropriated 75 per cent of the proceeds of the sale of tide lands within its harbors for their improvement, and will probably expend many millions of dollars in the construction of sea walls, bulkhead lines, wharves, streets, and other conveniences of commerce upon the water front of its harbors within the near future. The jurisdiction of the United States over the navigable waters of the State of Washington is for the promotion of the commercial interests of the country. The legislation of that State is actively engaged in the same direction and for the same purpose. Whilst the commerce of that State is rapidly assuming large proportions, and is not only of a national but of an international character, yet the State is more deeply interested, more vitally concerned, in the increase, in the encouragement, and in the good management of that commerce than anyone else can be, because its interest is direct, and every other interest is of an indirect or secondary character. Therefore it seeks and desires to act in harmony with the General Government in all plans and measures which have for their object the care, protection, and improvement of these great and growing commercial interests. It desires to coöperate with all agencies, whether local and municipal or State and national, in the work of securing, constructing, and maintaining a comprehensive system of harbor improvements commensurate with the enormous national and international commerce which will in the years to come be carried on in the ports of Washington.

In addition to the work of locating harbor lines and waterways, with which the Harbor Line Commission of the State of Washington is charged, we are also required by law to prepare and adopt plans for the permanent and substantial improvement of these harbors, subject to the approval of the Secretary of War. We are well aware of the fact that no action of the legislature of the State of Washington would be binding upon the Secretary of War, yet we have thought it not unreasonable to suppose that men who are charged with the care of great commercial interests, whether representing the General Government or the State of Washington, might agree upon some general plan or plans for harbor improvement, in accordance with which the sums appropriated or expended by each should be disbursed, either jointly or severally, but in such a manner that the greatest amount of benefit might be derived therefrom in carrying out the plans which might be found acceptable to both the State and the General Government. We hope

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for appropriations by Congress to assist in the improvement of our harbors, and should expect that appropriations so made should be expended under the direction of the officers of the General Government, but we also expect large sums to be expended by the State, and we desire that all efforts made and moneys used for this purpose should be devoted to the construction of a comprehensive system of permanent improvements which shall produce the best results for the commerce of both State and Nation. We are aware of the fact that the river and harbor act of Congress approved September 19, 1890, contains the following provision:

Where it is made manifest to the Secretary of War that the establishment of harbor lines is essential to the preservation and protection of harbors, he may, and is hereby authorized, to cause such lines to be established, beyond which no piers, wharves, bulkheads, or other works shall be extended or deposits made, except under such regulations as may be prescribed from time to time by him; and any person who shall willfully violate the provisions of this section, or any rule or regulation made by the Secretary of War in pursuance of this section, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding $1,000, or imprisonment not exceeding one year, at the discretion of the court for each offense.

But we believe that in making this provision for the location of harbor lines by the Secretary of War it was manifestly the intention of Congress to impose this duty upon that officer where no action was taken with reference thereto by the proper State authorities, or where such action, if taken, was an injury to navigation. Unless the latter contingency shall be shown to exist, it was evidently the purpose of Congress not to interfere with measures which might be taken for harbor improvements by the several States within their respective limits, and this is further evidenced by the fact that in section 10 of the same act an exception is made in favor of "bridges, piers, docks, and wharves, and similar structures erected for business purposes," which exception is clearly intended to cover the precise "structures" we propose to erect upon the areas within the harbor lines which we are now locating. We desire most earnestly, however, that there shall be not only no cause for controversy, real or apparent, now or hereafter, between the General Government and the State, but that we may have your active and cordial coöperation in the discharge of the important and responsible duties which have been devolved upon us by the State of Washington.

We therefore submit for your consideration and ask your approval of the following projects or preliminary plans for harbor improvement, as set forth on the maps which are herewith presented:

(1) For the harbor of Olympia. This consists of certain harbor lines, including bulkhead and pierhead lines, which have been located after a careful survey of the harbor, and with the best available engineering skill, with reference to the interests of commerce and navigation. With these lines there has been incorporated a project for a channel to be dredged from deep water to the head of navigation in the harbor, for which surveys have been made and plans, specifications, and estimates prepared and submitted by Capt. Thomas W. Symons, of the United States Engineer Corps, at Portland, Oregon. This channel, as adopted by us, is identically the same as that suggested by Capt. Symons, except that its lines have been slightly modified in order to make them conform to the harbor lines we have established in the same locality.

(2) For the harbor of Vancouver. This consists almost exclusively of a plan suggested by Maj. T. H. Handbury, after surveys, specifications, and estimates prepared by him for the closing, in whole or in part,

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of a slough or channel at the head of Hayden Island, to which we have added a project for dredging a channel 400 feet in width on the north side of the Columbia River, from the harbor of Vancouver to the deep water near the mouth of the Willamette River. It was the opinion of Maj. Handbury that the closing of the channel at the head of Hayden Island, thereby increasing the force and action of the current below the harbor of Vancouver, would open a channel through the bar which has formed below that harbor, but we are anxious to open a channel across this bar as soon as practicable, without waiting for the slow process of the river currents. With the exception of this channel the plan for which we ask your approval is identically that suggested by Maj. Handbury after a thorough and careful survey of the Columbia River in front of the city of Vancouver, and between that place and the mouth, of the Willamette River, from which point to the ocean there is usually an ample supply of water for at least ships of medium size or capacity.

(3) For Bellingham Bay. This project consists simply of the location of harbor lines, including bulkhead and pierhead lines, which have been established after a careful survey and with special reference to the interests to the navigation in front of the city of New Whatcom. In connection therewith we desire your approval for the restoration of the waters of the Nooksack River to their original channel through the Lummi Indian Reservation, by which they formerly flowed into the Gulf of Georgia. A collection of driftwood and débris of all kinds at the head of the old channel, as exhibited on the accompanying map, caused a deflection of the channel into Bellingham Bay, and enormous masses of sediment, sand, and alluvial deposit are being carried into that bay, and, unless diverted elsewhere, will before many years entirely ruin the navigation of the harbor of New Whatcom, which includes the upper part of Bellingham Bay. The people of that locality are willing to do this work at their own expense and return the river to its old channel if you will approve of the project.

The people of Olympia and Vancouver are also anxious, at their own expense and without waiting for the action of Congress, to begin the work of improving their harbors, as outlined in this letter, if the plans herein suggested shall meet with your approval. The rapidly growing needs of commerce in these localities make it important that the more urgent needs of better commercial facilities shall be provided at the earliest practicable moment.

Hoping that the importance of the subject may be a sufficient apology for the length of this communication, and that you may favor us with an early, and if possible with a favorable, consideration of the requests therein made,

I have the honor to be, very respectfully,

WM. F. PROSSER,
Chairman, Harbor Line Commission,
State of Washington.

Hon. STEPHEN B. ELKINS,
Secretary of War.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 5, 1892.

Respectfully returned to the Secretary of War.

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The harbor line commission of the State of Washington submits with request for approval projects and plans for the improvement of the harbors of Olympia, Vancouver, and Bellingham Bay, and for the establishment of harbor lines therein.

Congress has made no provision for the improvement of these harbors, and attention is invited to the provisions of section 18 of the river and harbor act of September 19, 1890, copy inclosed, which prohibits surveys being undertaken by the War Department with a view to improvements unless such surveys have been authorized by Congress. There is no authority of law known to this office whereby the Secretary of War can approve the projects presented. It appears to be the desire of the State commission to lay out certain land under water with a view to selling it.

In reference to the harbor lines, attention is invited to the provisions of section 12 of the act of September 19, 1890, which vests in the Secretary of War authority to cause the establishment of harbor lines where it is made manifest to him that such establishment is necessary for the preservation and protection of harbors. Under the provisions of this section, it is recommended that a Board of Engineers, to consist of Col. G. H. Mendell, Maj. Thomas H. Handbury, and Capt. Thomas W. Symons, Corps of Engineers, be constituted to consider and report upon the subject of harbor lines for the harbors of Olympia, Vancouver, and Bellingham Bay, and that the maps and projects submitted by the harbor line commission be referred to such Board.

With the approval of the Secretary the order convening the Board will be issued from this office.

THOS. LINCOLN CASEY,
Brigadier-General, Chief of Engineers.

[Third indorsement.]

WAR DEPARTMENT, *March 11, 1892.*

Approved as recommended by the Chief of Engineers.
By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 12, 1892.

Respectfully referred to Col. G. H. Mendell, Corps of Engineers, for consideration by the Board of Engineers constituted by Special Orders No. 16, Headquarters Corps of Engineers, March 12, 1892.

The expenses of the Board must be limited to the least sum possible as there is no appropriation for the harbors under consideration.

This paper, with its inclosures, to be returned with report of the Board.

H. M. ADAMS,
Major, Corps of Engineers, in charge.

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[Fifth indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., May 23, 1892.

Respectfully returned to the Chief of Engineers.

The report of the Board is found in three tracings* containing both a literal and graphic description of harbor lines recommended by the Board for the respective harbors of Vancouver, Olympia, and Bellingham Bay, sent in a separate package.

G. H. MENDALL,
Colonel, Corps of Engineers, Senior Member.

[Sixth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
May 31, 1892.

Respectfully returned to the Secretary of War.

The Board of Engineers appointed under authority of the Secretary of War (see second and third indorsements hereon), by Special Orders No. 16, Headquarters Corps of Engineers, March 12, 1892, to consider and report upon the subject of harbor lines for the harbors of Olympia, Vancouver, and Bellingham Bay, Washington, under the provisions of section 12 of the river and harbor act of September 19, 1890, recommends for the approval of the Secretary of War the harbor lines delineated and described upon the accompanying charts.

It is recommended that the line selected be approved, and that the Secretary place his approval upon the tracings submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

WAR DEPARTMENT, *June 3, 1892.*

The harbor lines selected by the Board are approved.

S. B. ELKINS,
Secretary of War.

DESCRIPTIONS OF THE HARBOR LINES (TAKEN FROM THE MAPS SUBMITTED).

HARBOR LINES IN OLYMPIA HARBOR.

For the harbor line: Beginning at a point on the line between townships 18 and 19 north, range 2 west, 328.1 feet west from the meander corner to sections 2 and 35, which point is in latitude 47° 5′ 00″.44, and in longitude 122° 54′ 4″.669; thence west 620.5 feet; thence south 14° 46′ west, 2,156.3 feet; thence south 16° 56′ east, 11,250 feet (at 2,996.9 feet on this line is the northwest and at 3,046.9 feet the southwest angle of the line bounding the east side waterway); thence south 42° west, 350.2 feet; thence north 16° 56′ west, 5,176.4 feet; thence south 84° 6′ west, 1,401.9 feet (at 725 feet this line just touches the northeast corner of the Main Street Wharf); thence south 5° 54′ east, 5,240 feet; thence south 84° 6′ west, 1,000 feet (at 19.8 feet on this line is the northeast, and at 119.8 feet the northwest angle of the line bounding the Capitol waterway, also the last 245.2 feet are coincident with the line bounding the Des Chutes waterway); thence north 5° 54′ west, 5,240 feet (the first 188.5 feet of this line are coincident with the line bounding the Des Chutes waterway); thence north 23° west, 4,060 feet (the first 52.2 feet of this line are coincident with the line bounding the west side waterway); thence north 30° 52′ west, 4,000 feet; thence north

* Not printed.

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54° 35′ west, 1,950 feet (this point is the initial point of the Butlers Cove waterway); thence north 10° 15′ east, 194.6 feet (this line also bounds the Butlers Cove waterway); thence west 609.7 feet (the first 118.1 feet of this line also bounds the Butlers Cove waterway) to the terminal point, which is on the line between townships 18 and 19 north, range 2 west, and 170 feet east of the meander corner to sections 4 and 33. It is in latitude 47° 5′ 1″.324, and in longitude 122° 55′ 57″.762.

HARBOR LINES IN VANCOUVER HARBOR.

Beginning at a point which is 2,844.32 feet south and 5,280 feet east of the stone monument set for the southeast corner of the Amos Short Donation Claim, said monument being at the foot of a balm of Gilead tree on the right bank of the Columbia River and at the south end of Main street in the city of Vancouver, also being 326.32 feet north and 2,550.95 feet west of the meander corner between sections 35 and 36, township 2 north, range 1 east, W. M.; thence for the outer harbor line north 64° 25′ 39″ west, 9,058.61 feet; thence north 52° 49′ 12″ west, 3,111.89 feet, to a point which is south 0° 44′ 45″ west, 374.92 feet from the southwest corner of the Amos Short Donation Claim; thence north 48° 13′ 52″ west, 3,470.24 feet, to a point which is south 278.15 feet from the meander corner between sections 20 and 21, township 2 north, range 1 east, W. M.; thence north 59° 50′ west, 3,107.9 feet, to the terminal point of the outer harbor line.

HARBOR LINES AND WATERWAYS AT NEW WHATCOM, BELLINGHAM BAY.

For the harbor line or outer limit of the reserved area: Beginning at a point on the meander line of the Pattle Donation Claim 1,448.5 feet east and 1,704.4 feet north from an iron bolt in solid rock which marks the southwest corner of the Pattle Donation Claim and is referred to in the notes of the Pattle and Morrison Donation claims; thence due west 731.72 feet; thence north 34° 55′ east, 401.45 feet; thence north 31° 36′ east, 2,035.71 feet; thence north 40° 39′ east, 947.71 feet; thence north 32° 7′ west, 1,380.33 feet; thence north 37° west, 2,191.35 feet; thence north 57° 23′ west, 6,984.73 feet; thence north 32° 37′ east, 600 feet to the terminal point, which is 2,379 feet south and 1,498.4 feet east of the meander corner to sections 22 and 23, township 38 north, range 2 east.

Whatcom Creek waterway shall begin at a point on the Government meander line of the Peabody donation claim 230.5 feet northerly from the stone monument marking the southwest fractional corner of the Peabody donation claim, thence north 44° 28′ west, 363.2 feet along the Government meander line of the Peabody donation claim; thence south 45° 12′ west to an intersection with the outer harbor line. The south line of the waterway shall commence at the above-described point of beginning and shall run on a parallel line with the north line of the waterway to an intersection with the outer harbor line.

I and J street waterway shall begin at a point on the Government meander line which is northwesterly 721.5 feet from the stone monument marking the southeast corner of the Roeder claim; thence north 65° 28′ west, 182.7 feet along said Government meander line; thence south 44° 30′ west to an intersection with the outer harbor line. The south line of the waterway shall commence from the above-described point of beginning and shall run on a line parallel to the north line of the waterway to an intersection with the outer harbor line.

The Squallicum Creek waterway shall begin at the meander post between fractional sections 23 and 24, township 38 north, range 2 east; thence following the Government meander line north 82° west 475.7 feet; thence south 36° 30′ west to an intersection with the outer harbor line; thence from above described point of beginning south 22° east 205 feet along Government meander line; thence on a parallel line to the north line of the waterway to an intersection with the outer harbor line.

HARBOR LINES AT FAIRHAVEN, BELLINGHAM BAY.

On September 1, A. D. 1891, among proceedings of the harbor line commission of the State of Washington, the following resolution was unanimously adopted:

Resolved, That the area reserved for wharfage and other purposes under control of the State along the water front of the city of Fairhaven, as provided by Article XV of the constitution of the State of Washington and the acts of the legislature relating thereto, shall be contained within the following metes and bounds, to wit:

For the harbor line on the outer limit of the reserved area: Beginning at a point on the meander line of the Pattle donation claim, which point is 1,704.4 feet north and 1,448.5 feet east of an iron bolt set in solid sandstone rock, the said bolt being the southwest corner of the Pattle donation claim as described in the field notes of

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the surveys of the Pattle and Morrison donation claims; thence west 731.72 feet; thence south 34° 55′ west, 748.91 feet; thence south 50° 51′ west, 987.67 feet; thence south 32° 4′ west, 1,473.81 feet; thence south 6° 35′ west, 847.24 feet; thence south 8° east, 752.33 feet; thence south 15° 14′ west, 404.38 feet; thence south 58° 50′ west, 627.4 feet; thence south 86° 33′ west, 1,185.33 feet; thence south 36° 54′ west, 3,247.48 feet; thence south 23° 7′ east, 1,726.92 feet; thence south 48° 46′ east, 904.4 feet; thence south 5° 32′ west, 750.54 feet; thence south 13° 26′ east, 1,467.54 feet; thence south 34° west, 252.13 feet; thence south 12° 20′ west, 825.63 feet; thence south 43° 5′ east, 783.01 feet; thence south 12° 23′ east, 945.9 feet; thence south 26° 55′ east, 1,174.84 feet; thence south 29° 11′ east, 2,011.67 feet; thence east 702.94 feet; thence north 2° 16′ east, 751 feet; thence east 31.85 feet; thence south 23° 41′ east, 208.69 feet; thence south 28′ west, 200.06 feet; thence south 17° 26′ east, 714.01 feet; thence east 345.64 feet; thence north 10° 21′ east, 884.11 feet; thence north 4° 22′ west, 579.23 feet; thence north 31° 43′ west, 850.95 feet; thence north 9° 49′ west, 703.22 feet; thence east 980.95 feet; thence south 41° 40′ east, 1,305.52 feet; thence south 24° 30′ east, 2,090.76 feet; thence south 12° 47′ east, 2,498.5 feet; thence east 307.62 feet; to a point near high-water mark on or about the quarter-section line of section 24.

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APPENDIX U U.

IMPROVEMENT OF WILLAMETTE RIVER, OREGON, AND OF LOWER COLUMBIA RIVER AND ITS TRIBUTARIES, OREGON AND WASHINGTON.

REPORT OF MAJOR THOMAS H. HANDBURY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Mouth of Columbia River, Oregon and Washington.
2. Construction of canal at the Cascades, Columbia River, Oregon.
3. Columbia and Lower Willamette rivers below Portland, Oregon.
4. Willamette River above Portland, Oregon.
5. Cowlitz River, Washington.
6. Youngs and Klaskuine rivers, Oregon.
7. Gauging waters of Columbia River, Oregon and Washington.

EXAMINATIONS AND SURVEYS.

8. Willamette River, Oregon, at Clackamas Rapids, Ross Island, and Corvallis.
9. Lower Willamette and Columbia rivers below Portland, Oregon.
10. Columbia River near Vancouver, Washington.

HARBOR LINES.

11. Establishment of harbor lines in Willamette River at Portland, Oregon.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, July 12, 1892.

GENERAL: I have the honor to submit herewith annual report for the fiscal year ending June 30, 1892, upon the work of river and harbor improvement in my charge.

* * * * * * *

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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U U 1.

IMPROVEMENT OF MOUTH OF COLUMBIA RIVER, OREGON AND WASHINGTON.

The project under which this work is being carried on was adopted in 1884. It contemplates providing a channel across the Columbia River Bar having a depth of 30 feet at mean low tide. This is to be effected by concentrating the water flowing over the bar and increasing the resultant currents to such a degree as to procure the desired depth. Any work for accomplishing this end must be more or less tentative in its character. The work which is now in progress is the building of a low-tide jetty, starting from Fort Stevens, on the South Cape, and extending in a westerly direction, with a slight curve to the south, out across Clatsop Spit, for a distance of 4½ miles, more or less, as circumstances may require, to a point about 3 miles south of Cape Disappointment. The jetty is constructed of stone, resting upon a mattress foundation about 40 feet wide and from 2½ to 5 feet thick. The stone extends to a level of 4 feet above mean lower low water. The material thus far has been placed in position from a jetty tramway supported upon piles driven along the line of the jetty and about 24 feet above the level of low tide. The tramway is a double-track 3-foot-gauge railroad, the tracks being 13 feet between centers, and 28 feet above the plane of mean low water. The material is landed at the wharf and transported to places over these tracks, which are built in advance of the main work.

Before the commencement of this work the channel or channels over this bar were very capricious in location and variable in depth. The depths are usually from 19 to 21 feet and the channels varied in number from 1 to 3 and in location through nearly 180° from Cape Disappointment to Point Adams.

The results of the jetty already constructed are very marked in the building up of Clatsop Spit and in the effects produced by the concentration of water upon the bar. There is now a straight out-and-in channel having a width of ¼ mile, with a depth nowhere less than 29 feet and for a width of 1 mile a depth of 27 feet. At the end of last fiscal year the shortest distance from the 30-foot curve on the outside to the same on the inside of the bar was 3,000 feet. This distance is now reduced to 1,200 feet. These depths refer to the plane of the mean of lower low waters.

The first appropriation for this improvement was made in the river and harbor act approved July 5, 1884. The total amount appropriated to the end of the present fiscal year for carrying out the project is is $1,337,500. The amount expended, including outstanding liabilities, is $1,313,168.88 leaving a balance of $24,331.12 applicable to the further prosecution of the work.

At the end of the last fiscal year the jetty tramway was at station 239 + 52, with the mattress work at station 235 + 40. Station 25 + 80 is regarded as the root or beginning of the jetty proper. During the month of July the tramway was extended 1,088 feet. Station 250 + 20 is regarded as the end of the jetty. This is 4¼ miles from the beginning at station 25 + 80. From this station east to the end of the present wharf the distance is 3,080 feet, making the distance from the end of the wharf to the outer end of the jetty a little over 4.8 miles.

In view of the results obtained by the jetty at the end of last fiscal year, as shown by the sounding taken at that time on the bar, it was

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deemed advisable to stop the construction of the jetty when it arrived at a point 4¼ miles from its inner end and await further developments, which would be shown by the sounding to be taken during June of this year. To give to the outer end of the jetty extra strength to resist the action of the waves in that locality, the tramway was widened for 300 feet back from the end so far as to permit of a third track being laid 13 feet south of the south tract. This arrangement permitted the laying of a foundation of mattresses 80 feet wide; on this rock was piled to a level of mean high water. The piles used in this locality were 65 feet long; they were driven into the sand from 25 to 30 feet. The action of the waves and tides would scour the sand down from 10 to 15 feet before the mattress could be put in place. When this was done it would fill back again and as rock was put on keep piling up against it. Extra precautions were taken to double driftbolt and strap the caps and stringers to the piles and put in additional braces from the end back for a distance for 6,000 feet. In the distance of 300 feet at the widened portion of the jetty 30,000 tons of rock were dumped.

Since the commencement of the work in 1884 there has been used in the construction of the tramway and its repairs 377,660 lineal feet of piling and 2,223,580 feet B. M. of lumber. The cost of the tramway has been approximately $6.50 per lineal foot. There has been used 18,414 cords of fascines. The mattress work in place has cost $4.50 per lineal foot.

Under the contract dated January 22, 1891, in force with Joseph E. Smith, 150,500 tons of rock were received during the year. The total amount of rock received from all sources since the commencement of the work is 478,890 tons.

About 25,000 tons of this rock was used in securing the root of the jetty and in protecting the buildings and railway between that point and the wharf. The balance has been distributed along the line of the jetty. From the end of the jetty back for a distance of 2,500 feet the rock is raised to a level of 4 feet above datum, for 13,000 feet it is at datum, for 5,200 feet it will average 4 feet above, for the remaining distance it will run from this level to high water. Near the inner end of the jetty it was found to be necessary to pile the rock well up toward the high-water line to protect the piling of the tramway from the heavy drift brought down by the river during the winter and spring. At places along the line of the jetty it was observed that there was a decided tendency during the last of the flood tides and the first of the ebb for the water to flow across the jetty in great volume and with considerable velocity. Where this was the case the sand would not deposit in the vicinity, but would be scoured out, increasing the area of the waterway. At these places rock was dumped in until this action ceased. It was found that when the jetty reached the height of about 4 feet above the mean level of low water the flow during both ebb and flood was under control. The sand was deposited to the level of low water and above, in many instances, on both sides of the jetty.

Under the contract entered into with Richard Hoyt, April 20, 1891, 1,768 cords of fascines and 3,528 poles were received. These were used in making the mattresses placed under the last 1,000 feet of the jetty.

The piles used during the year were purchased in open market at the rate of 9½ cents per lineal foot delivered at Astoria. The lumber was purchased in open market also, at $10 per 1,000 feet delivered at Fort Stevens.

On account of inclement weather and to give opportunity for general repairs that were needed to the tramway, the barges, towboats, and

rolling stock of the railway, the delivery of rock was suspended from the 20th of December to the first of March. It was necessary to make extensive repairs to four of the oldest barges belonging to the plant in order to keep them in anything like serviceable condition. This was done by written agreement with the lowest bidder after soliciting proposals for the work, at a cost of $1,750 each. The other repairs were made by the regular employés upon the work.

On June 9, 10, and 11 surveys were made upon the bar at the mouth of the Columbia River with the view to developing the present condition of the channel in that locality. The conditions were favorable for this work and the results make a very satisfactory showing. The soundings were reduced to the plane of the mean of lowest low waters and are shown upon the sheet herewith. The general outline of the low-water line as it now exists in the vicinity of the jetty is also shown. This survey shows an increase in the depth of the water over the bar to the northward of the deepest water of last year. The 27-foot channel is now about 1 mile wide and the 25-foot channel about 2 miles. This tendency of the body of the water to pass out more to the northward can be attributed, I think, to the southerly storms that prevail during the winter and spring.

What was the old south channel when the work commenced is gradually shoaling up on a line with the end of the jetty. In this vicinity, where there was at that time from 19 to 30 and 35 feet, there is now only about 17 feet. To the southward this channel is holding at the same depth as formerly. The north channel of that time is closing up, while the middle sands, with but 10 feet of water upon them, have entirely disappeared, and where this minimum depth was there is now 34 feet. These sands have been pushed out into the deeper water of the ocean, and now there is from 26 to 29 feet of water where they were. As a matter of course shoaling has taken place in this deeper water in front of the fore slope of the old bar, where this was deposited, but not to such an extent as to interfere with navigation. The indications from this survey are all favorable to a permanent depth of channel of at least 30 feet. The shortest distance between the curves of this depth on the two sides of the bar is now but 1,200 feet.

This improvement is already having a very marked effect upon the foreign commerce of the river. The commercial statistics herewith indicate an increase in the number and tonnage of these vessels. The indications for the coming season are that there will be a still greater increase.

Estimates for the year ending June 30, 1894.—It is estimated that $525,000 will be required to finish this work. Should $350,000 of this be appropriated for the fiscal year ending June 30, 1893, it is recommended that the balance, $175,000, be made available for the fiscal year ending June 30, 1894.

The original estimate for the construction of this work was $3,710,000; of this amount there has already been appropriated to June 30, 1892, $1,337,500. There was a balance on hand at that date of $24,331.12, exclusive of outstanding liabilities.

It is proposed to expend this and future sums appropriated in raising the jetty to a height of 4 feet above low water in those places that are not yet at that height, and in further strengthening the jetty. There is now about 13,000 feet that is at the level of mean low water. Experience has shown that it will not be safe to leave the jetty at this height. The first half of the tides flowing across the jetty, either ebb or flood, take the sand with them and scour channels. Especially is this the

case where there are low places in the jetty. It is only by building up the jetty that this cross-flow can be prevented. About 4 feet above low water seems to be the height required. The jetty towards the outer end will need to be well protected with large rocks to resist heavy seas. During the year Mr. G. B. Hegardt has continued to render intelligent and zealous service in local charge of this work. His report is herewith appended, to which attention is invited for further details pertaining to the work done.

APPROPRIATIONS.

July 5, 1884	$100,000
August 5, 1886	187,500
August 11, 1888	500,000
February 22, 1890	75,000
September 19, 1890	475,000
Total	1,337,500

Money statement.

July 1, 1891, balance unexpended	$274,710.46
June 30, 1892, amount expended during fiscal year	220,913.69
July 1, 1892, balance unexpended	53,796.77
July 1, 1892, amount covered by uncompleted contracts	29,465.65
July 1, 1892, balance available	24,331.12
Amount appropriated by act approved July 13, 1892	350,000.00
Amount available for fiscal year ending June 30, 1893	374,331.12
Amount (estimated) required for completion of existing project	175,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	175,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

REPORT OF MR. G. B. HEGARDT, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES ASSISTANT ENGINEER,
Fort Stevens, Oregon, July 1, 1892.

MAJOR: I have the honor to submit the following report of operations on the improvement of the mouth of Columbia River, Oregon and Washington, for the fiscal year ending June 30, 1892:

JETTY TRAMWAY.

At the end of last fiscal year the end of the tramway was at station 239+52 and the bracing carried to station 232+64.

The construction of the tramway was completed in July.

The extension during the year was 1,088 feet, which brings the end of the tramway and jetty to station 250+40. The bracing of the tramway was secured from station 232+64 to the end, a distance of 1,776 feet.

For the purpose of better securing the end of the tramway and the jetty, a spur track was put in at the end, joining the south track 300 feet from the end and having 13-foot centers. Each bent in the spur track was secured to the main bents in the tramway, thus forming a connected structure.

Sixty-five-foot piles were used for the tramway, with the exception of the last six bents, where 70-foot piles were driven.

The mean depth of water in which piles were driven was 12 feet, but before the mats could be sunk the sand would scour away to a depth of from 20 to 24 feet, the bottom generally seeking its level at about 22 feet below low water.

A few bents back from the end a cluster of four 75-foot piles were driven and allowed to stick up about 20 feet above the tracks. Between these four piles another pile, about 40 feet long and resting on the cap of the tracks, was secured with screw bolts and guys. On top of this pile was placed a ball beacon, 8 feet in diameter and

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made of hoop iron, as a mark for crafts entering the river. The top of the beacon is 70 feet above low water.

A great deal of extra work in reënforcing and repairing the tramway had to be done during the year. The months of December and January were a succession of violent windstorms, and, though the tracks were not damaged in any particular place, still they were considerably shaken up. The piles, caps, and stringers would work loose from the fastenings from the heavy sea running in over the spits. Several piles were washed away in different parts of the tramway, but principally in the last 3,000 feet. These were all replaced.

Extra driftbolts were put in the caps and stringers through every pile from the end and as far in as to station 190, a distance of about 6,000 feet, and iron straps, over the caps and spiked to the piles, on the two south piles from the end and in to station 225, a distance of 2,500 feet, and over the two north piles from the end to station 230, a distance of 2,000 feet.

In addition to this, longitudinal braces were put in, from pile to pile, between stations 236 and 228. Since this work has been done and the rock dumped into about low water, no difficulty was had in keeping the tracks in good running order.

Near station 230, where the sand spits on the south side of the jetty run so close in, is the place where the most trouble was experienced in keeping up the repairs to the tramway tracks.

Here during the winter months, after each storm, the piles on the south side would be washed away from the driftbolts, and the pile-driver had to be run out every time to pull them back in place or put in new piles.

The piles, caps, and stringers in the first part of the tramway, having been in about seven years, are getting to decay to a great extent, and during the last two years more or less repairing has been done to keep the tracks in good condition for running rock trains over them. The stretch where the most decay has taken place is between stations 30 and 43. Last winter some seventy new piles were driven between these stations and new caps and stringers put down for nearly the whole distance. With the repairs done last winter the tracks were put in a conditon to make them safe for another year or year and a half at the most.

Any additional repairing after this will be both expensive and difficult, as it is almost impossible to drive piles through the rock in the jetty. It would probably be cheaper as well as quicker to construct entirely new tracks alongside the present tramway than to attempt to repair the old tracks.

For the first 3,000 feet of tramway the rails are also getting pretty badly corroded and will not be safe for use after another year's work. The rails in both the tramway tracks were taken up to straighten the tracks from the end, and as far in as to station 210, a distance of 4,000 feet, and from this station and to shore where found necessary. All the crossings on the tramway were overhauled and new switch rails put down.

While running trains of rock out towards the end it has been necessary to employ three men on the tracks to take up the creeping of the rails, which is considerable, and keep the tracks in good running order.

Jetty.—The mattress work at the end of last fiscal year had been advanced to station 235+40. During the year the mattress work was completed to the end, or station 250+40, being an addition of 1,500 feet. The length of the jetty is 4¼ miles, station 25+80 being considered as the commencement or root of the jetty.

The inside mats were made from seven thicknesses of fascines, as was done last year. Throughout the length of the jetty mats were only sunk under the tracks and on the north or river side, but commencing at station 245, and running out to the end, mats were put down on the south side as well. At the 300-foot long spur track at the end mats were sunk on both sides and under the tracks, making the mattress work 80 feet wide. It had been the intention to continue to place mats on the south side of the jetty as far in as to station 235, but it was found impossible on account of the heavy swell which is constantly on so far out from shore.

The last mattresses were sunk early in September and after this time the weather was unusually severe.

In the last 300 feet of the jetty, including the spur track, very nearly 30,000 tons of rock was placed, bringing it up to from 4 to 9 feet above low water. This was done last fall, but during the winter months the top part of this mass of rock was partly washed away by the sea, and the height reduced to about 3 to 4 feet above low water. Only the heaviest kind of rocks, weighing from 6 to 12 tons each, were placed here, but the waves that strike the jetty toward the end are quite high and unbroken.

The total amount of rock received during the year was 150,500.8 tons and is by about 30,000 tons the largest amount received during any one year since the work commenced.

There seems to have been a settlement in the rock placed in the jetty of from 1 to 2 feet for most of the distance, though part of this apparent settling may have been

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caused, and probably was, by the rock being washed off by the sea. Part of the rock received has been placed where the settlement or washing off has taken place, some of it to raise the level of the rock to about 4 feet above low water, but the bulk of it towards the end of the jetty. The following approximate amounts were placed between the different stations: On the shore-protection spur 900 tons; station 22+44, 1,200; 44+100, 28,000; 100+170, 15,000; 170+200, 2,000; and from station 200 to the end the remainder, or 103,000 tons.

From the end of the jetty and back to station 225, a distance of 2,500 feet, the rock has been raised to a level of about 4 feet above low water, and from station 96 to station 44, a distance of 5,200 feet, to a height of from 3 to 5 feet above low water. Between stations 225 and 96 the rock is on an average up to low-water level.

No scouring away of sand has taken place at the end of the jetty. There has, on the contrary, been a filling in of sand on top of the mats of about 12 feet. The mats were sunk in 25 feet of water at low water, and the water is only from 12 to 14 feet deep there now. From the survey of the bar, made June 9 to 11 will be seen that the sands to the westward of the end of the jetty are getting shoaler, and also to be working out toward the sea. On the progress sheet accompanying this report are shown the sand spits that are dry at extreme low water in the vicinity of the jetty. The change is very marked from that of last year, and especially so on the south side.

On the drawing showing the soundings taken on the bar in June this year the full extent of the main spits on the south side of the jetty are shown. The extreme south limits of these spits were located by sextants from the surf-boat of the life-saving station here, the boat following the line of breakers as close as possible. The outline of the main spit was also located by the use of sextants, from the spit itself, at a run-out of 2 feet below mean lower low water.

Just south of the end of the jetty, where there is a break in the line of soundings, the water must be shoal, as it was breaking too heavy there to take any soundings at the time we were out in the surfboat.

The main portion of the main spit on the south side of the jetty is from 3 to 4½ feet above mean low water. The spit on the north side opposite the main one on the south side is about 2 feet above mean lower low water.

The other sands shown as bare at extreme low water are from 1 foot above to 1 foot below mean lower low water.

Delivery of rock was suspended December 21 and again resumed March 1. An attempt was made by the contractor to get rock for the jetty at Bugby Hole quarry. The rock proved to be very brittle, and could not be gotten out except in small pieces, and attempt was given up. The rock has been furnished from the Willamette River quarries as last year. All the towing of barges has been done by Government boats, as before.

The racing of the waves along the line of the jetty has almost entirely ceased, and takes place only after very severe storms.

Shore trestle.—In September, about 200 cords of fascines were placed under the tracks between stations 21 and 25, just back of the rock dumped in front of the tracks, and about 300 tons of small rock placed on top of it, to prevent the undermining of the rock in front of the tracks. When heavy sea rolls in, the waves break over the tracks here, and the water, when receding, cuts away the sand from between the piles and under the rock. Since the above work was done no trouble has been experienced at this place.

During the severe storms we had in December a great deal of rock in front of the shore-trestle tracks between stations 22 and 26 washed off, and it was necessary to dump about 600 tons of rock here to bring it up to the same level it was before the storm.

The shore trestle tracks have been subject to decay as much as the first part of the tramway tracks, and required repairing to put them in good condition.

Last year nearly all the piles had to be renewed, and this year the ties and some of the stringers had to be replaced.

Between stations 23 and 30 the tracks were torn up and new ties put in for both the tracks for the whole distance. From the first old wharf, station 4 to station 23, a large number of new ties were put in. The rails of the north track between stations 23 and 30 were so corroded that it was deemed best to take them up. This was done, and rails that were in the wharf tracks taken up and put down in the shore trestle track, those from the shore trestle being laid on the wharf instead, the danger there not being so great. This work was done in February during suspension of rock delivery. All the switches were taken up to allow new ties to be put down.

Wharves.—The severe storms experienced during the winter months, accompanied by high tides and heavy swells, did considerable damage to the wharf tracks. In December fifteen piles were washed out from under the wharf approach tracks. These were replaced at the time by new ones being dug in and blocked up. Shortly after delivery of rock had been suspended, in the early part of January, after another

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heavy storm, about forty-five piles washed away from under the same tracks. Some of these piles had been dug in, while others were jetted down.

In order to make a good job of the repairs, three of the parallel tracks leading to the wharf were torn up for a distance of over 300 feet and about 70 new piles put in. The pile-driver jet pump and one of the hoisting engines were fitted up and the piles hydrauliced down to a depth of 15 to 20 feet.

Every time a new wharf was built the tracks had to be changed and new and reinforcing piles were put in wherever most convenient in order to rush the work through, and in consequence the piles in the bents were irregular and like a network. Whenever a log would get in between the piles it would wrench them from the drift-bolts and out of place. When the repairs were made, all piles not in regular bents were taken out and new ones put in in line with those of the first track built, thus making a clear passageway between every bent.

The depth of water at the main wharf has not decreased during the year, being still 30 to 35 feet at low water. At the old wharf additional scouring has taken place and the depth of water is now about 15 feet.

Protection spur.—About 900 tons of rock was placed on this spur during the year in low places where rock had washed off. Several bents washed away during the year, and about 200 feet at the end are about ready to go.

The beach has flattened out very much from the end of the spur and to the dock and the surf comes up very close to the shore-trestle tracks on high tides. This spur should be extended to and connected with the dock before the winter storms commence.

It is a piece of work that has to be done before the completion of the jetty, and the sooner it is done the better.

Principal material received.

Rock	tons	150,500.8
Fascines	cords	1,767.92
Poles		3,528
Piles	linear feet	18,025
Lumber	feet, B. M.	213,971
Wood	cords	734.5
Coal	tons	884
Rails	do	20

Plant.—The whole plant has been kept in good repair during the year. All repairs to plant have been made on the works and in workshops of the place. The plant being built for the improvement of Coos Bay, Oregon, was completed.

Dump cars.—Car No. 11, of the old rocker style, was rebuilt as an experiment, with reinforced braces and stronger timbers. This style of cars, of which we have twenty-two, were all getting pretty well used up, having been in nearly constant use for about six years. These cars were evidently not built for as heavy-weight rock as has been used for the jetty here and the woodwork required constant attention to keep the cars in condition for service. The rebuilt car having proved satisfactory after being in use during four months of steady running, it was decided to rebuild the other twenty-one in the same manner. This was done during the months of February and March. The cars were all wrecked and the entire woodwork renewed. These cars are now much stronger than when first built and better adapted to the service. New car boxes were also made for these cars.

The receipt of rock during the year was the largest of any one year during the progress of the work, and the repairs have naturally been greater than before. The principal repairs, however, have been to car boxes. Twenty-eight new ones were made and forty-five thoroughly overhauled. The ironwork of fourteen of the geared dump cars has been scraped and painted, also the woodwork. U-straps were put on all of the forty geared dump cars, as a safeguard in case the ordinary fastenings of the brake beams should give away. The first twenty geared dump cars when built were not provided with truss rods for the center beams. Such were put on these cars during the winter. New patent dust guards were put in all the cars on the work.

Locomotives.—The ordinary running repairs during the working season were attended to.

During the suspension of delivery of rock, January and February, all the locomotives were thoroughly overhauled and put in first-class repair. Locomotive No. 1 had new pins and bushings made for all connections, brake cylinders bored out, new brake piston and rings, valves reset, and frame and tender scraped and painted. No. 2—new pins for all connections, new lagging on boiler, new wheels for the trailing truck, new coal box, new floor for the cab, one side of the cab renewed, frame scraped and painted. The drivers for this locomotive were sent to Portland to have the tires turned off, our lathe not being large enough to do the work. No. 3 had a new dry pipe put in, new wheels for the trailing truck, new lagging for the boiler, and frame scraped and painted. No. 4—new wheels were put on for the trailing truck, throttle valve reseated, new driving springs put in, and frame scraped and painted.

No. 5—the repairs to this were comparatively small, the locomotive being only a year old.

The boilers of all the locomotives were tested, as were also the steam gauges.

Derricks.—Three new derricks were made and put up in place of those in use, which were about two years old.

An additional derrick, complete, was made and is kept in reserve in case of breakdown.

Pile-driver.—After the repairs to the tramway the driver was laid up and woodwork painted. The iron work of the trucks has been scraped and given two coats of red lead.

Tug.—The deck of the *Mendell* was calked in September.

January 15 the *Mendell* was laid up for repairs, which were completed on the 29th. The repairs consisted of overhauling the high and low pressure cylinders and pistons, the valves, cross-heads, crank pins, and main journals, the condenser cleaned, circulating pump overhauled, boiler scaled and cleaned out. Indicator pipes were put in, capstan engines repaired, canvass put under pilot-house to prevent leakage, coal bunkers repaired, etc. The hull below water line was given one coat of copper paint and the hull and other woodwork painted.

Barges.—All the barges were more or less repaired while engaged in carrying rock from the quarry, the repairs being mostly made to the guards and sheathing.

Chafing plates for the anchors were put on all the barges.

Four additional hatches were cut in each barge to increase the circulation of air. The four oldest barges were taken to Portland for repairs, these being too extensive to be attended to here. The six other barges were taken to Youngs River for the winter, and there repaired by carpenters from here. These repairs consisted of repairing and renewing guards, chocks, bitts, towposts, sheathing, etc. Roofs of houses and hulls above water line were painted.

Shop.—The machinery in the shop has been increased by the addition of 12-inch shaper, the machinery and engine overhauled and scraped, and the tubes of the boiler expanded.

Miscellaneous work done.—One old Dow pump, badly damaged, was repaired by having a new yoke put in, cylinders bored out, and new piston rods made. Two Worthington and one wind-mill pump were also put in good repair.

One of the boiler feed pumps on the steamer *Cascades* was thoroughly overhauled, having the cylinders bored out, new pins made for the cross head, valves and valve seats reseated, etc.

For the improvement of Coos Bay, Oregon, the following work was done: Eleven geared, self-righting dump cars were made, completing the construction of the twenty built here.

Two matcars, used here in the construction of the jetty, were shipped to Coos Bay, there being no further use for them here.

Sixty-four hooks, for suspending inside mats while being made, were also sent at the same time.

Surveys.—June 9, 10, and 11 a series of lines of soundings were taken on the bar to develop the channel. These soundings show a straight-out channel about one-quarter of a mile wide, with a least depth of 29 feet, referred to the plane of the average of the lowest low waters. Last year's survey showed a 27-foot channel three-quarters of a mile wide and the 24-foot channel about 2 miles wide.

This year's soundings give the 27-foot channel a width of 1¼ miles, the 24-foot channel having the same width as before, or 2 miles. The scouring away of sand in the 27-foot channel of this year has all been to the northern or in a more straight-out course. Scarcely any change has taken place in the 24-foot channel, the contour lines being practically where they were last year. The 29-foot channel is about in the same place where the 27-foot channel was last year. Where the 29-foot channel passes through the crest of the bar the distance between the 30-foot curves has been decreased about one-quarter of a mile.

The spit ahead of the jetty is shown to have moved outward, and shoaler soundings were found between the 24-foot curve and the end of the jetty than was the case last year.

The results obtained by the jetty are certainly very gratifying, and it may not be too much to expect that, after the freshet in the Columbia River is over, there will be a 30-foot channel over the bar.

Miscellaneous.—Accompanying this report are the following drawings:

Plan and profile showing extent of jetty constructed June 30, 1892.

Survey of the mouth of the river made June 9, 10, and 11.

In closing this report, I wish to acknowledge the efficient and faithful assistance given me in my work by Mr. J. W. Stoneman, overseer.

Very respectfully, your obedient servant,

G. B. HEGARDT,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

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COMMERCIAL STATISTICS.

The following commercial statistics bearing upon the improvement of the mouth of the Columbia River were collected from the sources indicated, and are the most reliable that can be obtained.

Arrivals and clearances of vessels at Portland, Oregon, during the year ending June 30, 1892.

[From collector of customs Portland, Oregon.]

Vessels.	Coastwise.		Foreign ports.				Totals.	
			American.		Foreign.			
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Arrived in 1891 and 1892	183	228,444	7	4,838	99	129,397	289	362,679
Cleared in 1891 and 1892	137	183,504	35	25,096	106	137,430	278	346,030

Commerce, July 1, 1891, to June 30, 1892.

Exports	$6,646,642
Imports, entered for consumption	1,350,807
Imports, entered for transportation to other ports in the United States	642,393
Imports, entered for transit through the United States	214,165
Total value of exports and imports	8,854,007
Receipts from duties collected	595,312
Receipts from other sources	11,707
Total receipts	607,019

Arrivals and clearances of vessels and commerce at Astoria, Oregon, during the year ending June 30, 1892.

[From collector of customs, Astoria, Oregon.]

Vessels.	Coastwise.		Foreign ports.				Total.	
			American.		Foreign.			
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
Arrived in 1891 and 1892	622	542,455	9	4,020	90	117,973	721	664,448
Cleared in 1891 and 1892	587	543,766	18	13,918	61	88,626	666	646,310

Commerce, July 1, 1891, to June 30, 1892.

Exports	$1,226,048.06
Imports	129,738.98
Duties collected	103,594.89
Total receipts	$111,194.45

Gross annual tonnage passing in and out over Columbia River Bar, as reported by the collectors of customs at Portland and Astoria, is 2,019,467 tons.

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FROM RECORDS OF THE MERCHANTS' EXCHANGE, PORTLAND, OREGON.

Registered tonnage inward over Columbia River Bar from June 30, 1891, to June 30, 1892.

Month.	Deep-sea vessels.						Steam.				Coasters, American.		Total.	
	American.		British.		German, etc.		American.		Other flags.					
1891.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
July	....	.....	1	1,205	....	.....	31	26,736	2	2,482	6	2,056	40	32,479
August	1	1,462	3	3,714	....	.....	27	20,006	4	4,135	3	868	38	30,185
September	2	3,385	4	6,208	....	.....	25	19,520	2	2,533	6	1,841	39	33,487
October	....	.....	10	10,940	4	4,694	26	21,267	2	1,742	8	3,253	50	41,896
November	....	.....	21	29,943	1	1,007	25	23,383	2	2,491	2	793	51	57,617
December	1	1,036	11	15,736	....	.....	20	19,059	3	3,782	4	1,380	39	40,943
1892.														
January	1	1,469	21	28,809	2	2,248	21	15,994	3	3,404	4	1,773	52	53,697
February	1	1,931	3	3,781	....	.....	22	18,233	1	871	6	4,693	33	29,509
March	1	1,746	3	3,693	....	.....	19	15,108	1	1,565	4	1,984	28	24,096
April	....	.....	1	1,399	....	.....	25	18,905	1	1,662	5	1,288	32	23,254
May	4	6,574	2	3,244	....	.....	27	17,679	....	.....	6	2,658	39	30,155
June	....	.....	4	5,121	....	.....	23	16,564	....	.....	2	729	29	22,414
Total	11	17,603	84	113,793	7	7,949	291	232,454	21	24,667	56	23,266	470	419,732
Previous season	9	12,393	73	97,954	3	3,989	307	301,360	22	21,448	69	22,103	483	459,247

Registered tonnage outward over Columbia River Bar from June 30, 1891, to June 30, 1892.

Month.	Deep-sea vessels.						Steam.				Coasters, American.		Total.	
	American.		British.		German, etc.		American.		Other flags.					
1891.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
July	....	.....	4	4,724	....	.....	27	25,560	3	4,064	8	2,188	42	36,536
August	....	.....	1	1,312	....	.....	29	20,443	4	4,206	3	1,647	37	27,608
September	....	.....	2	1,977	....	.....	26	20,343	3	3,282	5	1,622	36	27,224
October	2	3,359	7	9,842	1	1,256	24	21,138	2	2,533	6	2,469	42	40,597
November	1	1,488	9	9,717	3	3,438	26	22,630	3	3,362	6	2,649	48	43,284
December	....	.....	3	4,904	....	.....	20	21,308	2	2,436	....	.....	25	28,648
1892.														
January	1	1,036	24	33,499	1	1,007	19	15,226	2	2,533	8	2,531	55	55,832
February	....	.....	20	27,787	....	.....	24	17,974	2	2,217	2	856	48	48,834
March	1	1,469	3	5,138	2	2,248	16	14,897	2	2,436	5	2,399	29	28,589
April	....	.....	4	4,786	....	.....	27	19,158	1	1,662	6	3,198	38	28,804
May	1	1,589	3	3,712	....	.....	29	18,842	....	.....	4	1,484	37	25,627
June	1	1,553	2	1,988	....	.....	22	15,160	....	.....	3	1,194	28	19,895
Total	7	10,494	82	109,386	7	7,949	269	232,679	24	28,731	56	22,237	465	411,478
Previous season	9	12,393	67	90,683	4	4,963	287	298,845	21	18,807	70	23,218	458	448,909

Comparative statement of principal exports for the past ten seasons.

WHEAT.

	Foreign.		Domestic.		Total.	
	Centals.	Value.	Centals.	Value.	Centals.	Value.
Season ending July 31—						
1883	1,761,754	$2,918,458	362,709	$560,338	2,124,463	$3,487,796
1884	2,276,809	3,712,253	311,941	477,725	2,588,750	4,189,978
1885	3,147,902	3,720,378	521,834	598,828	3,669,736	4,319,203
1886	3,971,756	4,979,841	1,349,740	1,602,805	5,321,486	5,582,646
1887	3,042,316	3,889,499	711,872	988,936	3,754,188	4,878,435
1888	3,203,108	3,783,208	1,259,263	1,485,189	4,462,371	5,268,397
1889	2,689,686	3,779,644	559,953	741,642	3,249,639	4,521,286
1890	1,752,879	2,210,950	343,690	420,151	2,096,569	2,631,101
June 30, 1890, to June 30, 1891	2,786,633	3,814,020	1,235,833	1,536,410	4,022,466	5,350,430
June 30, 1891, to June 30, 1892	3,563,562	5,713,710	977,677	1,503,310	4,541,239	7,217,020

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Comparative statement of principal exports for the past ten seasons—Continued.

FLOUR.

	Foreign.		Domestic.		Total.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
Season ending July 31—						
1883	353, 829	$1, 684. 919	139, 471	$708, 854	493, 300	$2, 393, 773
1884	334, 534	1, 556, 684	218, 846	945, 857	553, 380	2, 502. 141
1885	198, 208	796, 839	182, 316	656, 485	380, 523	1, 453, 324
1886	353, 869	1, 323, 877	187, 736	689, 708	541, 632	2, 013, 585
1887	383, 773	1, 412. 208	137, 908	548, 447	521, 681	1, 960, 655
1888	486, 456	1, 703, 926	158, 015	598, 670	644, 471	2, 302, 606
1889	510. 875	2, 039, 725	144, 184	584, 186	655, 059	2, 621, 911
1890	411. 751	1, 530, 731	111, 681	447, 275	523, 432	1, 978, 006
June 30, 1890, to June 30, 1891	489, 604	1, 834, 450	120, 556	502. 943	610, 160	2, 337, 393
June 30, 1891, to June 30, 1892	339, 058	1, 457, 670	129, 510	620, 210	468, 568	2, 077, 880

SALMON.

	Foreign.		Domestic.		Total.	
	Cases.	Value.	Cases.	Value.	Cases.	Value.
Season ending July 31—						
1883	367, 388	$1, 940, 991	280, 944	$1, 460, 181	648, 332	$3, 401, 172
1884	281, 060	1, 352, 498	267, 084	1, 308, 620	548. 144	2, 662. 118
1885	296, 285	1, 228, 441	363, 583	1, 494, 315	660, 138	2, 757, 756
1886	166, 697	725, 408	410, 800	1, 795, 994	577, 497	2, 521, 402
1887	159, 707	816, 707	372, 112	1, 925, 590	531, 819	2, 742. 297
1888	78, 754	466, 631	382, 793	2, 241, 281	461, 336	2, 707, 912
1889	107, 240	732, 805	270, 535	1, 903, 593	377, 775	2, 636, 398
1890	109, 489	720, 935	354, 528	2, 492, 210	464, 017	3, 213, 145
June 30, 1890, to June 30, 1891	22, 951	110, 615	270, 715	1, 441, 094	293, 666	1, 551, 709
June 30, 1891, to June 30, 1892	84, 854	424, 270	340, 662	1, 709, 935	425, 516	2, 134, 205

Table of comparative values of exports for the last ten years.

	Foreign.	Domestic.	Total foreign and domestic.
Year ending July 31—			
1883	$6, 553, 227	$6, 383, 266	$12, 936, 493
1884	6, 638, 850	6, 014, 321	12, 653, 171
1885	5, 857, 057	6, 699, 776	12, 556, 833
1886	7, 032, 026	9, 480, 996	16, 513, 022
1887	6, 196, 722	9, 507, 183	15, 703, 905
1888	5, 991, 990	8, 788, 887	14, 780, 877
1889	6, 634, 989	9, 562, 815	16, 197, 804
1890	4, 534, 441	7, 868, 770	12, 403, 211
Year ending June 30—			
1891	5, 806, 535	8, 368, 605	14, 175, 140
1892	7, 725, 720	8, 308, 775	16, 034, 425

Comparative statement of deep-sea tonnage for the past eight seasons.

INWARD.

Flag.	1884–'85.		1885–'86.		1886–'87.		1887–'88.		1888–'89.		1889–'90.		1890–'91.		1891–'92.	
	No	Tons.	No	Tons.	No	Tons.	No	Tons.	No	Tons.	No	Tons.	No	Tons.	No	Tons.
American	17	22, 044	14	19, 169	9	11, 839	8	10. 656	9	13, 241	6	8, 336	9	12, 393	11	17, 603
British	97	91, 737	132	137, 138	130	113, 837	95	117, 072	77	92, 483	47	61, 812	73	97, 954	84	113, 793
Norwegian	...	...	1	901	...	...	2	2, 187	2	1, 744	...	...	...	...	...	...
German, etc	4	3, 613	3	2, 622	2	1, 475	1	1, 726	4	3, 876	1	974	3	3, 989	7	7, 949
Total	118	117, 394	150	159, 830	141	127, 151	106	131, 591	92	111, 344	54	71, 122	85	114, 336	102	139, 345

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Comparative statement of deep-sea tonnage for the past eight seasons—Continued.

OUTWARD.

Flag.	1884–'85.		1885–'86.		1886–'87.		1887–'88.		1888–'89.		1889–'90.		1890–'91.		1891–'92.	
	No	*Tons.*	*No*	*Tons.*	*No*	*Tons.*	*No*	*Tons.*	*No*	*Tons.*	*No*	*Tons.*	*No*	*Tons.*	*No*	*Tons.*
American	20	24, 790	14	19, 323	7	9, 280	3	3, 857	12	16, 611	5	8, 050	9	12, 393	7	10, 494
British	97	92, 555	119	124, 073	111	119, 716	98	122, 344	75	89, 731	52	67, 428	67	90, 683	82	109, 386
Norwegian	...	.....	1	901	...	.....	2	2, 137	2	1, 744	...	.....	...	.....	...	.....
German, etc ...	4	3, 618	3	2, 622	1	851	2	2, 350	4	3, 976	1	974	4	4, 963	7	7, 949
Total	121	120, 963	137	146, 919	119	129, 847	105	130, 688	93	112, 062	58	76, 452	80	108, 039	96	127, 829

NOTE.—From 1884 to 1890 the season begins on July 31; from 1890 the period covered is from June 30.

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CONSTRUCTION OF CANAL AT THE CASCADES, COLUMBIA RIVER, OREGON.

The general scope of the improvement which it is desired to effect at the Cascades of the Columbia River includes a reach of about 4½ miles, where the river rushes through a narrow gorge in the Cascade Mountains. The fall in the distance is about 45 feet at high water and 36 feet at low water. The principal obstruction to navigation occurs at the upper end of the reach known as Upper Cascades. The project for the improvement contemplates that the river should be improved below the Upper Cascades by removing bowlders and projecting points in the bed and banks so as to give good navigable water from its lowest up to a 20-foot stage. The fall at the Upper Cascades is to be overcome by digging a canal of 3,000 feet in length across the neck of a low, projecting spur, around which the river is forced at the entrance to the gorge, and placing in this a lock and other suitable structures, which would permit of the passage of boats up to a 20-foot stage of water in the river, this lock and canal to be so arranged that, should the future necessities of commerce so demand, additional structures may be added which will permit of navigation at much higher stages.

The first part of this project, that of improving the river below the foot of the Upper Cascades, is essentially finished.

The difference of level between the head and foot of the canal as now established is 15 feet at high water and 24 feet at low water, and difference in height between high and low water at the foot is 54 feet, and at the head 45 feet. The plan on which the future work in the canal, with its lock and accessories, is to be prosecuted, has for its object to make this portion of the river available for navigation to a stage up to 20 feet at the earliest possible moment, with the funds that are from time to time appropriated for the purpose.

At the commencement of the present fiscal year there was available for the prosecution of the work $204,691.71. At that time the principal work in progress was cutting stone, there being about fifty cutters employed. Other operations, excepting current repairs, were suspended on account of high water in the Columbia River. By the 1st of August the water had receded sufficiently to permit the lock pit to be pumped out. On the evening of the 7th the water was practically all out of this. Preparations were at once made for resuming the work of placing concrete and setting stone in the north wall of the masonry of the lower lock and guard gate. Quarrying stone was resumed about the 20th of July. Concreting and stone setting was resumed August 20. Work was pushed forward actively until December 5, when it became necessary to suspend the making of concrete and stone setting. On

the 11th of December stone cutting was discontinued. By the 19th the whole laboring force was discharged. The office force was moved to Portland on that date and employed during the winter in making up estimates of the season's work and in the preparation of detailed drawings for future work. The property at the works during this time was left in charge of watchmen. On April 4 the office force returned and the stone cutting and quarrying was resumed, and continued to June 30. At this date the balance available for the prosecution of the work is $17,833.60.

When work was suspended in December the lock pit was allowed to fill with water, and on resumption in the spring it was not deemed advisable to pump this out and attempt any concrete work until after the summer rise in the river. In order that the concrete work may not be delayed for want of cut stone after the construction of the masonry is once commenced, it is necessary for the cutters to have a considerable supply ahead at the beginning of the work. With this object in view a force of about forty cutters has been employed since the season commenced.

The progress during the year towards completion is represented by the following general results: There were cut 2,074 cubic feet of dimension granite, 27,117 cubic feet dimension basalt, and 50,019 cubic feet basalt face stone. There were quarried 2,110 cubic yards of dimension stone and 604 yards of rubble from the bowlders found on the ground leased for this privilege.

Quantities of stone laid: In lock walls, 334 cubic yards of granite, 651 cubic yards basalt dimension stone, 2,003 cubic yards basalt face stone; in canal walls, 37 cubic yards basalt face stone, and 223 cubic yards dry rubble. Sixty-seven cubic yards of concrete culvert pipe, 39 inches in diameter and 6 inches thick, were laid in the south lock wall.

The amount of concrete made and placed during the year was 17,899 cubic yards. There were used in this 15,720 barrels Portland cement, 8,475 cubic yards sand, 13,984 yards gravel, and 1,001 yards broken stone. Seventy-seven sections of concrete pipe 3 feet long, 39 inches in diameter, and 6 inches thick, were made.

Quarrying from basalt bowlders found in the vicinity has been carried on to the extent of 2,110 cubic yards of dimension stone and 604 cubic yards of rubble.

The excavation for the year amounted to 8,033 cubic yards. All the excavated material was used in filling in behind the walls. This excavation includes the 2 feet removed from the foundation for the south walls just before putting down the concrete, and the bed rock removed to make place for a portion of the masonry of the upper lock gate in the south side.

The masonry constructed during the year is the north abutment of the lower lock and guard gates, except the coping, and about 300 feet of the south wall of the lock chamber. The total amount of this masonry is 21,214 cubic yards.

The condition of the work June 30, 1892, is in general terms as follows: The lower canal walls have been completed to reference 90, top being reference 92, from the abutments of the lower guard gates nearly to the lower bulkhead, the completed length of the south wall being 293 feet and the north wall 275 feet; the lower lock and guard gate masonry has been completed to reference 108 on both sides of the canal; the south wall of the lock chamber has been completed to the same reference for a length of about 345 feet; the south wing wall of the upper guard gate has been completed to reference 114 for a length of 97 feet; the

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upper canal walls are nearly completed from the site of the upper guard gate to the upper bulkhead; the slope outside of the berm on the north side of the canal has been paved from the lower bulkhead to beyond the center of the lock chamber a distance, approximately 800 feet, and from the upper bulkhead down a distance of 300 feet; on the south side of the canal the slope has been paved from the lower bulkhead to the lower lock gate, a distance of about 600 feet, and from the upper bulkhead nearly to the upper guard gate a distance of about 500 feet; the excavation of the lower canal from the lower bulkhead to the lower guard gate has been practically completed; the excavation in the lock chamber has been completed, except 2 feet left on the bottom to be removed just before putting down the concrete floor; the excavation for the abutments of the upper lock gate has been partially completed; and from the site of this gate to the upper bulkhead also partially completed. In addition to this a large amount of necessary incidental work has been done, in the way of constructing temporary protection works, quarters, shops, etc., and the establishment of a complete plant for carrying on the work rapidly and economically.

The principal work yet to be done is approximately as follows:

Excavation:		
Earth and loose rock	cubic yards	285,757
Bed rock	do	57,782
Total	do	343,539
Masonry construction:		
Granite	do	1,210
Basalt dimension stone	do	4,287
Basalt face stone	do	4,277
Concrete	do	46,311
Side wall at entrance	do	31,311
Paving slopes	do	19,800
Total	do	107,196

The gates, valves, pumps, engines, and other maneuvering machinery are to be provided. There is also a large amount of filling in and grading to be done. A general idea of the masonry work constructed and yet to be constructed can be had from the tracing herewith, showing work completed and proposed.

There are on hand, June 30, approximately, 3,000 cubic yards of cut stone of various kinds and 457 cubic yards of rough basalt stone ready for cutting.

The buildings and plant are now in a good state of repair and everything is in readiness to push the work forward as rapidly as the funds available and other circumstances will permit.

In my last annual report mention is made of the fact that the agents of the State of Oregon were permitted to enter upon the Government grounds at the Cascades and had commenced the construction of a portage railway thereon, this road with its two inclines was finished about the middle of September. The first boat to reach the upper incline from The Dalles arrived September 15; the first boat to reach the lower incline from Portland arrived September 20. These two boats ran regularly from September 22 to January 12 of this year, their freight and passengers being transported over the portage railway. On this last date the service was discontinued on account of cold, stormy weather, and ice in the river between the Cascades and The Dalles. The boats began their regular trips again February 14 and continued until May 16, when the lower boat was taken off on account of high water, the

river being then 20 feet above low water; the difficulty was in making the landing at the lower incline. Although the boat is of small power it experienced very little trouble in ascending the lower rapids, but as it approached the foot of the main rapids it was obliged to keep near the Washington shore, and to cross the swift current diagonally to the landing place on the Oregon shore. The landing at all stages is necessarily on the upstream side of the portage incline. At the higher stages a cross current sweeps over the lower end of this incline, putting the boat in danger of being carried upon the piles or striking heavily against the wharf boat. When the canal is completed and the incline removed this trouble will be avoided.

During the year there were about 18,150 passengers and 5,000 tons of freight transported by these two boats.

For further detailed information relative to the work carried on during the year, reference is invited to the report herewith of my assistant, Lieut. Harry Taylor, Corps of Engineers, U. S. Army, who has been in local charge since November 14, 1891, and who has manifested a commendable zeal and intelligence in the discharge of the duties of the position. From the beginning of the year to this date, a period when most of the active work was performed, Lieut. Edward Burr, Corps of Engineers, U. S. Army, was the assistant in local charge. At that time much to my regret he was relieved from duty under my orders and assigned elsewhere.

The estimated amount, June 30, 1892, to be appropriated for completing this work is $1,745,500. The amount estimated that can be profitably expended during the fiscal year ending June 30, 1894, is $1,419,250.

COMMERCIAL STATISTICS.

The Cascades of the Columbia River are in the collection district of Willamette. The nearest port of entry is Portland, Oregon, 65 miles distant by river. The nearest light-house and works of defense are at the mouth of the Columbia River, 150 miles distant. The amount of revenue collected at Portland for the year ending June 30, 1892, is $607,019.

APPROPRIATIONS.

June 14, 1876	$90,000	July 5, 1884	$150,000
June 18, 1878	150,000	August 5, 1886	187,500
March 3, 1879	200,000	August 11, 1888	300,000
June 14, 1880	100,000	September 19, 1890	435,000
March 3, 1881	100,000		
August 2, 1882	265,000		1,877,500

Money statement.

July 1, 1891, balance unexpended		$208,483.71
June 30, 1892, amount expended during fiscal year—		
Portland office	$190,646.11	
Treasury Department	4.00	
		190,650.11
July 1, 1892, balance unexpended		17,833.60
Amount appropriated by act approved July 13, 1892		326,250.00
Amount available for fiscal year ending June 30, 1893		344,083.60
Amount (estimated) required for completion of existing project		1,419,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1894		1,419,250.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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REPORT OF LIEUTENANT HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cascades Locks, Oregon, June 30, 1892.

SIR: I have the honor to submit the following report of operations for "Improving Columbia River at Cascades, Oregon," for the year ending June 30, 1892.

I assumed local charge of the work on November 14, 1891, relieving First Lieut. Edward Burr, Corps of Engineers, on that date. At the time I assumed charge it was near the end of the working season, but the work was in full progress, with everything running smoothly and systematically.

The river and harbor act approved September 19, 1890, appropriated $435,000 for continuing this improvement, and the approved project for the expenditure of this appropriation calls for the completion of the masonry of the lower lock and guard gates, and the building of the lock wall and the masonry of the upper lock gates on the land side to the height of about 26 feet, with allowance for necessary additional excavation, and for plant, operating, and incidental expenses; the work to be done by hired labor and the purchase of material.

During the winter and early spring of 1891 work had been carried on under the approved project, and up to the end of June, 1891, the work had been the construction of the south wall of the masonry of the lower lock and guard gates, together with the necessary excavation, stone cutting, preparation and repair of plant, and all other operations incidental to this work. Preparation had also been made for commencing the north wall masonry for these gates, including the cleaning up of the foundation and shifting tracks and derricks, both in the pit and overhead. The work was in progress when the annual rise in the Columbia River caused a suspension of all work in the pit on May 4, 1891.

At the beginning of July then there was no work in progress except stone-cutting, and overhauling and repairing plant.

The river commenced to fall in the early part of July, and preparations were made preparatory to pumping out the pit as soon as the water should be low enough. The water having fallen sufficiently the pumps were started on August 1, and the water was practically out of the pit by the evening of the 7th; but on account of the leak in the bulkhead the water was troublesome for about two weeks, until the river had fallen some 5 feet or more, to about 85 on gauge No. 2.

As soon as the water was out of the pit (August 8) preparations were begun for resuming the work of concreting and stone-setting in the north wall of the masonry of the lower lock and guard gates. Concreting was commenced August 19, and stone-setting August 22.

The quarrying had been commenced on July 17th and work in the sand pit on August 14, so that on August 22 the work was in full progress again.

From August 22 until October 16 the work of concreting and stone-setting was confined to the north wall of the masonry of the lower lock and guard gates. This wall was practically completed on October 16, and the shifting of the derricks, engines, and tracks to their positions for work on the south (or land side) wall of the lock chamber commenced. These changes were completed on the 19th, and concreting and stone-setting were commenced in the south wall on the 19th and 21st, respectively. A length of about 300 feet was put under construction and completed to reference 108, both concrete and stone, on December 5, 1891.

As soon as the wall was finished the laying up of the plant commenced. Engines and derricks were taken out of the pit, the pump stand moved into position for pumping after the next high water and weighted down, the inclined trestle and track in the pit weighted and the work suspended for the winter.

The excavation for the extension of the south wall of the lock-chamber wall was commenced on October 30 and carried on until December 16.

The excavation was not quite completed, but as all other work was stopped and the weather very unfavorable it was not considered advantageous to finish the excavation at that time.

The work in the sand pit was suspended December 5, in the quarry November 16, and stone-cutting December 11, 1891.

The office force was moved to Portland December 19, and the work left in charge of the overseer and the necessary watchmen.

The office force was employed in Portland in the preparation of the reports and estimates of the last season's work, in the preparation of the detailed drawings of the masonry of the upper lock and guard gates, and of the shop drawings of the lower lock and guard gates, until April 4, 1892, when it was again moved to Cascade Locks.

As soon as the weather was favorable in the spring, 1892, preparations were made for the resumption of quarrying and stone-cutting. No attempt was made to lay concrete, as the funds remaining from the last appropriation would have been completely exhausted in about a month by the force necessary to carry on that work.

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Quarrying and stone-cutting were both resumed on April 8, 1892, and have been carried on continuously since. The stone-cutting during the spring has been mainly on the dimension stone for the masonry of the upper guard gate.

The work then, for the year ending June 30, 1892, has been the construction of the north abutment of the lower lock and guard gates, the construction of about 300 feet of the south wall of the lock chamber, the excavation necessary to complete this wall, quarrying and cutting stone, the repairs of plant, and all other operations incidental to this work.

The condition of the work on June 30, 1892, is, in general terms, as follows:

The lower canal walls have been completed to reference 90 from the abutments of the lower guard gates nearly to the lower bulkhead, the completed length of the south wall being 293 feet and the north wall 275 feet, the abutments of the lower lock and guard gates have been completed to reference 108 on both sides of the canal; the south (land side) wall of the lock chamber has been completed to reference 108, for a length of about 345 feet; the south wing wall of the upper guard gates has been completed to reference 114 for a length of about 97 feet; the upper canal walls have been nearly completed from the site of the upper guard gates to the upper bulkhead; the slope outside the berm on the north side of the canal has been paved from the lower bulkhead to beyond the center of the lock chamber, a distance of, approximately, 800 feet, and from the upper bulkhead down a distance of a little less than 300 feet; on the south side of the canal the slope has been paved from the lower bulkhead to the lower lock gates a distance of about 600 feet, and from the upper bulkhead nearly to the upper guard gates, a distance of about 500 feet; the excavation of the lower canal from the lower bulkhead to the lower guard gates has been practically completed; the excavation in the lock chamber has been completed, except 2 feet left on the bottom to be removed just before putting down the concrete floor; the excavation for the abutments of the upper lock gates has been partially completed, and from the site of the upper guard gates to the upper bulkhead the bulk of the excavation has been completed.

The work already accomplished, exclusive of all incidentals, such as the construction of temporary protection works, quarters, shops, etc., and the establishment of a complete plant for carrying on the work rapidly and economically, is approximately as follows:

Excavation:		
Earth and loose rock	cubic yards	164,564
Bed rock (conglomerate)	do	238,302
Total	do	402,866
Masonry construction:		
Granite	cubic yards	662
Basalt dimension stone	do	1,001
Basalt face stone	do	2,891
Concrete	do	32,041
Side walls at entrances (cut basalt facing, rubble backing)	do	16,283
Paving slopes (dry rubble)	do	9,657
Protection wall on right	do	24,816
Total	do	77,351

The work still to be done is approximately as follows:

Excavation:		
Earth and loose rock	cubic yards	285,757
Bed rock	do	57,782
Total	do	343,539
Masonry construction:		
Granite	cubic yards	1,210
Basalt dimension stone	do	4,287
Basalt face stone	do	4,277
Concrete	do	46,311
Side walls at entrances	do	31,311
Paving slopes	do	19,800
Total cubic yards		107,193

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The materials used during the past year, for both concrete and stone masonry, were the same as during the last three months of last year. The character of these materials, the proportions, and the plant and methods used in incorporating the concrete, and in handling the concrete and stone were so fully and minutely described in Lieut. Burr's annual report dated June 30, 1891, that any further description is unnecessary. The only important piece of plant purchased was a pumping outfit, consisting of a 6-inch centrifugal pump and engine, to replace a similar outfit which had become worn-out by long and continuous use. The only change of any note was made in the overhead traveler in the stone yard. In this the power had been communicated from the engine to the driving wheels which gave the motion up and down the length of the yard through a worm gearing. The speed was slow and the worm gearing had given much trouble, heating and breaking and causing much delay. The worm gearing was taken out and replaced by pinions and wheels. The speed up and down the yard is now a little more than three times what it was before, it takes less steam, and it has run without a hitch. The increased speed of the traveler will allow more cutters to be worked under the sheds than has heretofore been possible.

The amount of concrete made and placed during the year was 17,899 cubic yards. This was all mixed by machinery and placed by chute. Of this amount 836 cubic yards were placed in the south wing wall of the upper guard gates, and the remainder in the abutments of the lower lock and guard gates and the lock chamber walls. The cost of the concrete in the wing wall was somewhat greater than the average cost of the whole, due to the greater distance of the wall from the mixers, requiring more labor to transfer the concrete from the point of manufacture to the point of use. The proportions varied from 1 of cement, 2 of sand, and 4 gravel or broken stone, to 1 of cement, 4 of sand, and 8 of gravel or broken stone, depending on the final disposition of the concrete. The proportion 1:2:4 was used in the foundations of the walls and in the bottom of the canal in stopping leaks in the bed rock; the proportion 1:3:6 for the lower 14 feet of the lock walls and lower 10 feet of the abutments, and near the top of the walls the proportion was reduced to 1:4:8.

In making 17,899 cubic yards of concrete there were used 15,720 barrels of Portland cement, 8,457 cubic yards of sand, 13,984 cubic yards of gravel, and 1,001 cubic yards of broken stone. The average product was 1.14 cubic yards of concrete per barrel of cement and 1.19 cubic yards per yard of gravel and broken stone. The average materials used per cubic yard of concrete were 0.878 barrels of cement, 0.473 cubic yards of sand, 0.781 cubic yards of gravel, and 0.056 cubic yards of broken stone. The cement includes such as was used dry, amounting to 136 barrels.

In connection with the concrete, the manufacturing of the culvert pipe was continued. The pipe was made in sections 3 feet long, 39 inches internal diameter, with walls 6 inches thick. The concrete was made in the proportion 1:2:4, and the gravel was passed through a half-inch screen.

Seventy-seven sections of this pipe were made, containing 51 cubic yards of concrete. The total cost was $654.51, and the cost per linear foot was $2.83. The cost of setting the pipes is included in the cost of setting stone.

The sand and gravel for the concrete were obtained from the same pit as last year. The proportions of the two materials varied somewhat at times, but as a rule the proportion of gravel ran higher than it did when the pit was first opened. This was an advantage, as it required proportionally less crushed stone, and the gravel, as shown in previous reports, makes a better and cheaper concrete than the broken stone.

An estimated quantity of 15,457 cubic yards (in place) of material was taken from the pit. After washing and separating there were obtained from this material 8,712 cubic yards of sand, and 13,984 cubic yards of gravel, which were used in the manufacture of the concrete or for making mortar; and in addition 1,035 cubic yards of cobbles were rejected by the screens and used for filling behind the lock walls. The average cost of sand and gravel in the bins, after washing, was 71 cents per cubic yard.

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The cost of the concrete in detail was as follows:

Items.	Total cost.	Cost per cubic yard.
Labor:		
Mixing	$4,687.19	$0.262
Placing	9,021.38	.504
Timbering	1,216.28	.068
Testing	793.79	.044
Total	15,718.64	.878
Materials:		
Cement	52,962.46	2.958
Sand and gravel	16,055.65	.897
Broken stone	1,781.09	.100
Other materials	1,483.54	.083
Total	72,282.74	4.038
Total for 17,899 cubic yards	88,001.38	4.916
Culvert pipes, 51 cubic yards	654.51	.....
Total for fieldwork	88,655.89	4.939
Plant dropped	170.87	.009
Engineering	1,968.25	.110
Incidentals	15,217.02	.848
Total 17,950 cubic yards	106,012.03	5.906
Plant	1,841.63	.103
Aggregate	107,853.66	6.009

The charge for plant is made such that the total of "plant dropped" and "plant" shall be proportionate to the amount of work to be done by the plant, and the charges for "engineering" and "incidentals" are for proportionate shares of all the expenses incidental to carrying on the work and maintaining buildings and plant in proper repair.

The stone masonry laid during the year was part of the masonry of the lower lock and guard gates, and part of the south wall of the lock chamber, as previously described. It includes the stone finish to the face of the wall and sills, and stone facing for certain parts of the culverts, cable alleys, and engine pits. The account also includes the cost of constructing so much of the north wall of the lower entrance as was necessary to connect that previously built with the lock masonry.

The stone masonry of the lock is of three kinds—granite quoin stones and facings for the miter sills and valve chambers of the main culverts, basalt dimension stone, and basalt face stone. These stones were obtained in the same manner as last year, and the same requirements in cutting and laying were maintained. The stones of the lower lock and guard gate sills were anchored to the bed rock by wedge bolts of Norway iron 14 feet long, 1¼ inches in diameter, which were thoroughly driven home and grouted in place.

The connecting portion of the canal wall was built in the same manner as last year. The main body of the wall is of rubble, laid dry, and the face is of quarry-faced ashlar laid in Portland cement mortar and bonded into the rubble body.

The following amounts of stone were laid during the year: In the lock walls 334 cubic yards of granite, 651 cubic yards of basalt dimension stone, 2,003.1 cubic yards of basalt face stone, and 67 cubic yards of concrete culvert pipes. In the canal walls 37 cubic yards of face stone and 223 cubic yards of dry rubble. This was laid between July 1 and December 31. The total dimension and face basalt stone laid during that time, 2,691.1 cubic yards, exceeded the amount quarried, 1,213.4 cubic yards, by 1,477.7 cubic yards. The difference was made up from three sources—stone which had been quarried and cut last year, stone which had been quarried but not cut last year, and stone which had been quarried and partially cut during previous years. Of the cut stone there was used 625.1 cubic yards, of the rough stone, 306.5 cubic yards, and of the stone which required recutting, 546.1 cubic yards. On December 31 there were on hand 612.3 cubic yards of dimension and face basalt, 477.1 cubic yards of rough basalt suitable for cutting, and 1,688.2 cubic yards of stone similar to that which was recut.

Since stonecutting commenced in April there have been expended for cutting 917 cubic yards of rough basalt. The amount thus expended is more than the amount quarried during the same time by 19.9 cubic yards. There were obtained 790.7 cubic yards of finished cut stone. No stone has been recut. There are then on

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hand, June 30, 1,403.0 cubic yards of cut stone, 457.2 cubic yards of rough basalt, and 1,688.2 cubic yards of stone similar to that which was recut.

Cost in detail of stone laid.

Items.	Granite.		Dimension.		Face.		Culvert.		Canal.		Total.
		Cubic yds.		*Cubic yds.*		*Cubic yds.*		*Cubic yds.*		*Cubic yds.*	
Transporting	$181.03	.542	$352.84	.542	$1,085.68	.542	$36.31	.542	$140.92	.542	$1,796.78
Setting	755.77	2.263	1,473.07	2.263	4,532.56	2.263	151.61	2.263	588.33	2.263	7,501.34
Cement and sand	230.83	.691	449.93	.691	1,384.38	.691	46.31	.691	25.50	.098	2,136.95
Stone	24,644.28	73.780	17,583.09	27.009	39,276.41	19.607	.....	.....	704.50	2.710	82,208.28
Other materials	499.33	1.495	973.25	1.495	2,994.65	1.495	100.17	1.495	388.70	1.495	4,956.10
Total	26,311.24	78.771	20,832.18	32.000	49,273.68	24.598	334.40	4.991	1,847.95	7.108	98,599.45
Plant dropped	346.53	1.038	274.55	.422	649.40	.325	4.42	.066	24.42	.094	1,299.32
Engineering and superintendence	583.85	1.748	462.57	.710	1,094.14	.546	7.44	.111	41.15	.159	2,189.15
Incidentals	4,548.19	13.621	3,603.42	5.535	8,523.39	4.255	57.98	.866	320.61	1.231	17,053.59
Aggregate	31,789.81	94.138	25,172.72	38,667	59,540.61	29.724	404.24	6.034	2,234.13	8.592	119,141.51

Stonecutting was in progress at the beginning of July, 1891, and was continued until December 11, with as large a force as could be advantageously worked. Work was then suspended until April 8, 1892, when cutting was again resumed. The work since then has been carried on with about two-thirds the number of cutters that could be worked with the present facilities.

The stonecutters had also been at work during May and June, 1891, while other work was suspended on account of high water. Stone setting did not begin until August 22, but even with nearly four months' cutting ahead, the setting progressed so rapidly that at the beginning of December the masons had very nearly caught up with the cutters. The cutters were also helped by using some of the stone which had been cut in previous years, for use in the side walls of the entrances. The stone selected was of the proper rise and the beds and joints were already cut, but the face had been left rough. All the cutting necessary to fit this stone for use was to cut the face down to rough punched.

Nearly all the stone for the lower lock and guard gate abutments had been cut previous to July, 1891, so that the cutting of last fall was confined principally to face and dimension stone for the lock-chamber walls.

Since the work was resumed in April the cutting had been confined, as far as possible, to the dimension stone for the abutments of the upper lock gate. The dimension stones for one abutment are now almost all cut ready for laying.

The character of the stone and of the cutting were the same as last year.

The following summary gives the details of the cutting for the year, both as to quantities and cost:

	Granite.	Dimension basalt.	Basalt face.	Total.
Stone cut ..... number	76	1,486	2,647	4,209
Stone cut ..... cubic feet	2,073.8	27,116.8	50,019.3	79,209.9
Stone cut ..... square feet	4,262.4	53,575.9	83,689.4	141,527.7
Stonecutters' labor ..... hours	2,770	29,964	29,669	62,403
Average per hour ..... cubic feet	.75	.91	1.69	
Average per hour ..... square feet	1.54	1.82	2.82	
Cost for cutting ..... per square foot	$0.50	$0.44	$0.30	
Cost for cutting ..... per cubic foot	1.03	.86	.45	
Cost for stone ..... do	1.36	.32	.29	
Total cost ..... do	2.39	1.18	.74	
Total cost of stone cut	4,949.37	32,208.37	36,895.99	$74,053.73

The quarry work was carried on to supply the basalt required for face and dimension stone. The quarrying during the year has been done on the land adjoining the canal grounds on the east, the privilege for which was obtained last year. During the year there were obtained 2,110.5 cubic yards of dimension stone and 603.9 cubic yards of rubble. No rubble was hauled in from the quarry during the last six months as the storage ground for this stone had become very crowded and it will be cheaper to leave it at the quarry until such time as it may be needed than to haul in

now and rehandle it, as much as would be necessary. As the rubble split out incidentally with quarrying, the dimension stone during the spring was not hauled in from the quarry, no account is made of it. This increased the cost of the dimension stone somewhat as all the charge for quarrying went to that while heretofore it has been divided between the dimension stone and the rubble.

The total cost of quarrying during the year, including the 14 cents per cubic yard for the quarry right, was $16,505.89. The average cost per cubic yard was $6.08; the cost per cubic yard for dimension stone was $7.25, and per cubic yard for rubble, $2. These items include the cost of transporting the stone to the yards.

The excavation for the year amounted to 8,033 yards. This includes the 2 feet removed under the wall just before putting down the concrete, and the bed rock removed east of the part of the south wall under construction in preparation for the completion of this wall and the south abutment of the upper lock gate. As the high water of 1891 did not cover the guard fence at the lower entrance no sediment was found in the canal when it was pumped out. The total cost of the work was $10,087.40, which is $1.26 per cubic yard. The cost here given includes excavating and dumping.

All of the excavated material was used in filling behind the walls. The cobbles which were rejected by the sand washers, to the amount of 1,035 cubic yards, were also used as filling, and in addition strippings from the sand pit to the amount of about 462 cubic yards were also used as filling. The total cost of the filling was $2,378.08.

The metal work for such portions of the lower lock and guard gates as are embedded in the wall had been ordered the year before. These were received and embedded in the masonry.

Snubbing hooks for maneuvering and making fast were manufactured and placed in that portion of the lock wall constructed.

The usual office records were kept to supply all desired details of costs and quantities. The detailed drawings of the masonry are practically completed. The working drawings for the stonecutters for the upper lock gate are all finished and those for the upper guard gate very nearly so. The details of the gates and the shop drawings are well advanced.

The cost of the work for the year may be summarized as follows, proportioning engineering, superintendence, and incidentals to the various accounts according to their totals:

Concrete masonry	$106,012.03
Stone masonry	119,141.51
Excavating	10,087.40
Lock gates	5,499.89
Maneuvering machinery and appliances	1,721.34
Filling behind walls	2,378.08
Total for lock construction	244,840.25
Plant in excess of that dropped	1,968.61
Total cost for the year	242,871.64

Under the authority granted by the Secretary of War the State of Oregon, by its agents, entered upon the canal grounds during May, 1891, and commenced operations upon the construction of a portage railroad. The road was finished during September, and the first boat reached the upper end of the road September 15 and the lower end September 20. The boats in connection with the road commenced running regularly September 22 and continued until January 12, 1892, when they were laid up on account of the cold, stormy weather and the ice in the river between here and The Dalles. The boats began their regular trips again February 14 and continued until May 16, when the lower boat was taken off on account of high water. No transferring by the road has been done since. When the lower boat stopped running in May the river stood at 92 on the lower gauge, just 20 feet above assumed low water. The boat was taken off more on account of the danger and difficulty of making a landing than on account of the difficulty of reaching the landing place. Although the boat is of small power she had very little trouble in coming up through the lower rapids, but as she approached the foot of the main rapids she was obliged to keep over near the Washington shore, and to make the landing had to cross the swift current diagonally to the landing place on the Oregon side. The landing at all stages is necessarily on the upstream side of the portage incline and at the higher stages a strong current sweeps over the lower end of this incline, putting a boat in danger of being carried down onto the piles of the incline or being driven heavily against the wharf boat. When the canal is completed and the incline removed, as it necessarily will be, this trouble will be avoided and boats can easily ascend the lower rapids and make the lower entrance of the canal until the river is considerably above the stage at which the boat stopped this year.

A summary of the weather and water-gauge records is transmitted herewith.
The following drawings relating to the work are also transmitted:
Sheet 1, showing the work finished and that proposed.
Sheet 2, showing the dates and amounts of the work already done on the lock-chamber walls and lower-entrance walls.

Very respectfully, your obedient servant,

HARRY TAYLOR,
First Lieutenant of Engineers.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

U U 3.

IMPROVEMENT OF COLUMBIA AND LOWER WILLAMETTE RIVERS BELOW PORTLAND, OREGON.

The object of this improvement is now to make and maintain a navigable channel from the city of Portland, Oregon, to the sea, having a low-water depth of 25 feet. There is included in this reach 12 miles of the Willamette River and 98 miles of the Columbia, measured along the deep-water channel. Before the commencement of the improvement in accordance with previous projects the low-water depth of channel at the shoalest places was between 10 and 15 feet. At the end of the present year there is a low-water depth of 20 feet throughout the entire distance, except at the points in Cathlamet Bay, where there is but 19 feet. The average rise of the tide in this bay is 7 feet.

The original project under which this improvement has been carried on with modifications and extensions was adopted in 1877. Some dredging work had been done previous to that time. It contemplated that a navigable low-water channel having a depth of 20 feet should be maintained by means of permanent constructions to protect the banks, contract the rivers in wide places, direct the currents, and control the amount of water that should pass through sloughs having a detrimental influence upon the main channel. While these constructions were being put in place and until their influence was fully developed dredging was resorted to in several localities to give a temporary relief to commerce. Works of a permanent character have been erected in the Willamette River across the head of Swan Island Chute; at the head of Willamette Slough, to control the amount of water passing into that channel; also along the left bank of the river from that point to its mouth, to prevent erosion and excessive widening of the river; also across other sloughs and channels near the mouth of the Willamette River, to control its waters and those of the Columbia in that vicinity. Permanent structures were placed in the Columbia River at St. Helens, Burke Slough, and Martin Slough, all of which have produced very beneficial effects upon the navigable channel in their vicinity. During the time that these were in contemplation or process of construction dredging was resorted to to give temporary relief.

The amount expended by the United States in this improvement since the adoption of the project of July 1, 1877, is $649,805.97. It appears that previous to that date $221,780.46 had been expended in various operations looking to the improvement of the Willamette and Columbia rivers between Portland and the sea. The aggregate of the appropriations and allotments, including proceeds from sales of property to other appropriations, up to June 30, 1892, is $889,745.71. In addition to this amount the citizens of the city of Portland have in various ways

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expended a considerable sum, the exact amount of which can not now be ascertained, in assisting to keep open a deep channel to the sea.

The amount available for this work at the end of the present fiscal year is $15,686.88.

Work done during the fiscal year ending June 30, 1892.—The map of the Columbia River between Cathlamet and Point Ellis, opposite Fort Stevens, that was being made at the end of last fiscal year was completed. This covers a reach of 24 miles in extent and in the widest portion of the river. A survey of the river at Martin Island, covering a reach of 3 miles and including the shoal at that point, was made during last December. During last November a resurvey of the reach, about 5 miles in extent, at Walker Island was made. These were made with the view to close observation of the effects of the works of improvement soon to be constructed at these points. The map of the Willamette from the southern limit of Portland to the mouth of the river was also completed.

The high water of last August in the Columbia washed away the earth around the east end of the dam at the head of Martin Slough. Before this could be repaired there was an opening eroded 142 feet wide and from 24 to 42 feet deep. This slough and the one just above, known as Burke Slough, were the original cause of the Martin Island Shoal. This opening was closed during September and October. It was effected in the following manner: Two rows of piles were driven 6 feet apart, with piles in each row 6 feet from each other. The piles were sawed off 6 feet above low water and those of each row connected by waling pieces outside and also by longitudinal planks spiked to the inside down to low water and 1 foot apart. Fascines were filled in between the rows of piles to their tops and weighted down with rocks. A thick mattress of fascines was placed in front of and below the rows of piles and weighted down with rock. Brace piles were placed on the lower side to further strengthen the dam. The bank where the dam joins the shore was graded down and revetted for a short distance both above and below with fascines and rock. The old portion of the dam was strengthened and repaired where its material had settled. In this work there were used 60 piles, having an average length of 46 feet, 1,270 cords of brush, 3,010 tons of rock, and 8,000 feet of lumber. The total cost of the repairs was $8,500.

The dam at Burke Slough was strengthened by the addition of 200 cords of fascines and 500 tons of rock. The cost of this repair was $1,290.

The project proposed for closing the chute behind Swan Island in the Willamette River having received the approval of the Chief of Engineers, proposals for doing the work were advertised for. One received from Hoffman & Bates being the lowest, a contract was entered into with this firm, October 16, 1891, for furnishing the material in place necessary for this work. The project consists in closing this chute to all water up to a 4-foot stage and forcing it down the channel on the east side of the island, by this means increasing the current over Swan Island Bar and deepening the channel in that locality. The length of the dam is 6,570 feet. It was constructed by driving two rows of piles 4 feet apart from center to center, the piles in each row 6 feet apart and each opposite the interval in the other row. Fascines are placed in alternate layers perpendicular and parallel to the line of the dam and fastened by wire sufficient to hold them together until they can be sunk with rock. At its base the dam was 25 feet wide and became narrow as it approached low-water line. Brush with rock to hold it down thus

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formed the main part of the dam, the piles preventing any portion of it being washed away. It was the original design that all the piles should be sawed off at a uniform height of 4 feet above low water and connected together in each row by waling pieces bolted to them. As the piles were driven from the north end southward to about the middle of the dam a deposit of sand was made on the lower side, and this built up in some portions 4 and 5 feet above low water. In these portions the waling was either omitted on placed above the 4-foot level. To prevent this deposit from being scoured out at any time a mattress of fascines was put over it and covered with rock. On the south half of the dam where the original design could be carried out, where the waling pieces were bolted on, planks were spiked to the piles on the inside down to low water to prevent stone from rolling out. Fascines were placed between the rows on the top of those already in place and loaded down with rock.

Work was commenced under the contract October 29, and by its terms should have been finished within ninety days from its date. It was pushed as rapidly as practicable, but owing to the river remaining at an unusual height for this season of the year the work could not be finished at the specified time. An extension of time was asked and granted until April 30, 1892. By this time all the material required for the dam was in place according to specifications, excepting that 830 piles remained to be sawed off. The estimated cost of this, at 15 cents each, will be deducted from the retained percentage of the contractors before final settlement is made.

Since the dam was completed it has been submerged by backwater from the Columbia River. Its effect upon the bar at Swan Island would, under this condition, be nothing. The results will be developed after the next Willamette high water.

The following material was furnished in place under this contract:

42,679 linear feet piles, at 14¼ cents	$6,188.45
3,016.11 cords of fascines, at $2.65	7,992.69
15,058.69 tons of rock, at 60 cents	9,035.20
69,301.4 feet, B. M., lumber, at $12	831.61
1,769 pounds spikes, at 3¼ cents	57.48
5,230 pounds wire, at 3½ cents	183.05
1,452 bolts, at 30 cents	435.60
Total	24,724.08
Less $124.50 for piles not sawed off	24,599.58

On the 15th of September the chain bucket dredge belonging to the city of Portland, known as the *City Dredge*, with its tender, the tug *Vaughn*, were placed at the Government service, and, after employing the necessary crew, set to work at the Swan Island Bar in the Willamette River. This shoal was at that time giving trouble to deep-sea vessels. The old cut had not been entirely cleared out to 20 feet depth during the preceding season. Dredging operations were continued at this point until the end of October, when the dredge and outfit were returned to the city authorities and by them turned over to the Port of Portland Commission for work elsewhere. The total amount of material removed from Swan Island Bar during the season was 21,860 cubic yards, at a cost of 12½ cents per cubic yard, including repairs and all other expenses.

A project for improving the Lower Willamette and Columbia rivers so as to secure a navigable channel having at low water a depth of 25 feet from Portland to the mouth of the Columbia, was called for by the river and harbor act approved September 19, 1890. The report upon

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this, with drawings and estimates, was submitted by me to the Chief of Engineers under date of September 8, 1891. This project, with slight modifications, suggested by the Division Engineer, and approved by the New York Board of Engineers, to whom it was referred by the Chief of Engineers, was forwarded to Congress by the Acting Secretary of War as the project "for the improvement of the navigation of the Willamette and Columbia rivers between Portland and the Pacific Ocean." The reports in this case, together with the drawings submitted, were published as H. R. Ex. Doc. No. 38, Fifty-second Congress, first session.

When it became evident that the work in progress at the mouth of the Columbia River would produce a channel over that bar having a depth of 30 feet at low water, the citizens of Portland, desirous of holding their commercial supremacy over all other shipping points in the northwest, saw at once that all sailing vessels coming inside the bar must come to their wharves, be loaded and depart without lighterage and at a minimum of port charges. To await the slow operation of getting funds from the General Government for carrying out the proposed project for obtaining this necessary deep channel might lose them this supremacy and jeopardize their commercial prosperity. In view of this fact they obtained from the legislature of the State of Oregon an act creating a separate district within the county of Multnomah, to be known as the Port of Portland. The inhabitants of this district are declared to be a corporation. The act declares:

The object, purpose, and occupation of said corporation, The Port of Portland, shall be to so improve the Willamette River at the cities of Portland, East Portland, and Albina, and the Willamette and Columbia rivers between said cities and the sea as that there shall be made and permanently maintained in said Willamette River as said cities and in the said Willamette and Columbia rivers between said cities and the sea a ship channel of good and sufficient width and having a depth at all points at mean low water both at said cities and between said cities and the sea of not less than 25 feet.

For the purpose of carrying out this object the Port of Portland is authorized to borrow from time to time such sums as may be necessary, not to exceed in the aggregate $500,000, and to issue its bonds therefor; and also to levy a tax upon the property within the district sufficient to pay the interest on these bonds, and to do such temporary work as may become urgently necessary.

The power and authority given this corporation are vested in a board of commissioners composed of fifteen members.

This commission at once took measures for carrying out the object for which it was organized. Permission was granted to it by the Secretary of War to enter upon the improvement of the river in accordance with the project approved by him, but with the distinct understanding—

That the expenditure of the funds of the Port of Portland shall not be made by the Government engineer, neither shall he exercise any authority over said works or their execution, and that the United States shall not incur any liability on account of said works; *and provided further*, That the officers of said Port of Portland shall permit the officers of the Corps of Engineers, War Department, in charge of work on the Willamette and Columbia Rivers, to examine the work done, to see that the whole is carried on in accordance with the approved Government plans. And further it shall be distinctly understood that the War Department does not counsel, advise, or encourage the expenditure proposed by the Port of Portland.

Under this permission the Port of Portland has practically finished the following work called for in the approved project, between the foot of Swan Island and St. Johns, 4,000 feet of diking; at Postoffice Bar 6,300 feet of diking. The work at these two places was practically

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finished April 30. This is all the permanent work in the Willamette River, called for by the project. Since their completion the dikes have been covered by back water from the Columbia. Under these conditions these dikes will have little or no effect upon the channel. When the Columbia River recedes and they can direct the currents of the Willamette, favorable results may be expected.

In the Columbia River 11,750 feet of diking was built at Walker Island. This was completed May 28.

The 15,000 feet of diking at Snag Island in Cathlamet Bay, called for by the project, is now under contract by the Port of Portland, and in process of construction.

In addition to the above work the Port of Portland has removed with the city dredge 32,725 cubic yards of material from the bar between the foot of Swan Island and St. Johns, leaving at that place a channel 100 feet wide, 21 feet deep at low water; also 40,205 yards from Postoffice Bar, leaving a channel 150 feet wide, 21 feet deep; also 24,650 yards from the bar at Walker Island, leaving a channel 100 feet wide, 20 feet deep.

Of the work called for by the project, there are the additions to the present dike at St. Helens and the dike at Martin Island Bar that have not been commenced, although practically the whole of the dredging is yet to be provided for.

Estimates for the fiscal year ending June 30, 1894.—At the time of writing this report the effect of the work done under the project for obtaining a 25-foot channel from Portland to the sea by the Port of Portland can not be ascertained. The Columbia River is at its high summer stage and over the top of all the dikes, excepting those in process of erection in Cathlamet Bay. Whether this work will have to be strengthened or supplemented with other work in order to attain the object in view can not now be stated. The estimated cost of the work to be done under the project, that has not been entered upon by the Port of Portland, is $303,600. Should $150,000 of this amount be provided for expenditure during the fiscal year ending June 30, 1893, then it will be necessary to provide the remaining $153,600 for carrying on the work during the fiscal year ending June 30, 1894, which amount can be profitably expended during that year.

Money statement.

July 1, 1891, balance unexpended	$61,912.22
June 30, 1892, amount expended during fiscal year	43,752.94
July 1, 1892, balance unexpended	18,159.28
July 1, 1892, amount covered by uncompleted contracts	2,472.40
July 1, 1892, balance available	15,686.88
Amount appropriated by act approved July 13, 1892	150,000.00
Amount available for fiscal year ending June 30, 1893	165,686.88
Amount (estimated) required for completion of existing project	153,600.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	153,600.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

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Abstract of sealed proposals for furnishing and delivering in place material for constructing a low-water dam at Swan Island, Willamette River, Portland, Oregon, opened at 12 m. October 5, 1891, by Maj. Thomas H. Handbury, Corps of Engineers, at Portland, Oregon, after fourteen days' public notice.

No.	Name and address of bidder.	Piling (45,340 feet).		Lumber (181,152 feet).		Bolts (2,267).		Spikes (34,000 pounds).	
		Rate.	Total.	Rate.	Total.	Rate.	Total.	Rate.	Total.
		Cents.				*Cents.*		*Cents.*	
1	McKenzie & Glen, Portland, Oregon	16	$7,254.40	$18.50	$3,351.31	24	$544.08	4½	$1,530
2	Hoffman & Bates, Portland, Oregon	14½	6,460.95	12.00	2,173.82	30	680.10	3¼	1,105
3	John Waldorf, Portland, Oregon	15	6,801.00	16.00	2,898.43	31	702.77	4	1,360
4	Perry Hinkle, Portland, Oregon	10	4,534.00	13.60	2,463.67	20	453.40	3	1,020
5	Joseph E. Smith, Portland, Oregon	16	7,254.00	17.00	3,079.58	25	566.75	4	1,360
6	Smith & Burton, Portland, Oregon	12	5,440.80	14.00	2,536.13	29½	668.77	3	1,020
7	Pacquet & Smith, Portland, Oregon	9½	4,307.30	16.00	2,898.43	30	680.10	3¼	1,105
8	Robert Wakefield, Portland, Oregon	8¾	3,967.25	13.50	2,445.56	23	521.41	3¼	1,105
9	William Colwell, Skamokawa, Wash	12	5,440.80	12.00	2,173.82	22	498.74	3¼	1,105
10	Antonelli & Co., Portland, Oregon	19	8,614.60	20.90	3,786.08	18¼	413.72	4	1,360
11	C. W. Brown, Portland, Oregon	17½	7,934.50	10.50	1,902.09	30	680.10	5	1,700

No.	Name and address of bidder.	Wire (20,000 pounds).		Fascines (2,700 cords).		Rock (15,000 tons).		Aggregate.
		Rate.	Total.	Rate.	Total.	Rate.	Total.	
		Cents.						
1	McKenzie & Glen, Portland, Oregon	4	$800	$3.50	$9,450	$0.95	$14,250.00	$37,179.79
2	Hoffman & Bates, Portland, Oregon	3½	700	2.65	7,155	.60	9,000.00	27,274.87
3	John Waldorf, Portland, Oregon	4	800	3.45	9,315	.75	11,250.00	33,127.26
4	Perry Hinkle, Portland, Oregon	¼	50	2.98	8,046	.75	11,250.00	27,817.64
5	Joseph E. Smith, Portland, Oregon	4	800	3.50	9,450	1.22½	18,375.00	40,885.73
6	Smith & Burton, Portland, Oregon	3 9/10	720	2.73	7,371	.83⅓	12,500.00	30,256.70
7	Pacquet & Smith, Portland, Oregon	4½	900	2.75	7,425	.78	11,700.00	29,015.83
8	Robert Wakefield, Portland, Oregon	3 9/10	720	3.15	8,505	.74¼	11,212.50	28,476.73
9	William Colwell, Skamokawa, Wash	3 43/100	716	2.50	6,750	.75	11,250.00	27,934.36
10	Antonelli & Co., Portland, Oregon	4½	900	3.25	8,775	.83	12,450.00	36,299.40
11	C. W. Brown, Portland, Oregon	4¾	950	3.25	8,775	.98	14,700.00	36,641.69

COMMERCIAL STATISTICS.

This work is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

Statement of traffic on the Columbia and Lower Willamette rivers, not including deep-sea vessels, for the year ending June 30, 1892.

These figures have been collected from the various steamers and transportation companies doing business on the river.

	Tons.
Passengers (3,228,429)	242,132
Grain	50,431
Lumber (feet 185,328,302)	240,926
Live stock	15,112
Sheep	5,006
Coal	34,200
Wool	3,891
General merchandise	558,091
Total	1,149,789

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List of steamers plying on the Upper Willamette, Lower Willamette, Columbia, and Cowlitz rivers, Oregon and Washington.

Name of vessel.	Tons.	Draft.		Name of vessel.	Tons.	Draft.	
		Ft.	*In.*			*Ft.*	*In.*
Albina No. 2	150.51	2		Manzanilla	129.87	3	
Alice V	41.28	4		Maria	184.58	3	
Albina	85.26	1	8	Mascot	199.46	3	
Alliance	213.52			Mayflower	23.90		
Altona	189.68	2	3	Messenger	54.53		
Annie	6.61			Michigan	597.19	15	6
Argonaut	20.35	10	9	Milwaukee	29.70	2	
Astoria	76.16			Modoc	327.55	5	
Astorian	234.24	2	6	Northwest	301.98	1	3
Augusta	40.90			No Wonder	235.30	3	
Brazee	4.99			N. S. Bentley	401.42	1	6
Bonita	376.94	6		O. K.	47.76	4	6
Brisk	1.05			O. & C. R. R. Ferry	255.92		
C. M. Belshaw	14.20			Orient	429.76	5	
Carrie F	10.64			Ocean Wave	507.34		
C. W. Rich	17.07			Ocklahama	394.19	6	
Chilkat	106.45			Oregon	1,642.28	20	
City of Kalama	2.33			Oswego	21.43	3	6
City of Frankfort	133.47			Queen	23.75		
Columbia	1,746.14	20		Quinnat	4.20		
Cricket	43.55			R. P. Elmore	42.76	8	
Cyclone	19.06	5	6	Regulator	334.88		
D. S. Baker	566.22			Ramona	114.14		
Dalles City	296.38			R. R. Thompson	912.06	10	6
Despatch	13.47			Rowena	4.50		
Dolphin	60.36			Rush	12.38		
Eclipse	25.03			R. Miler	41.39		
E. L. Dwyer	24.44			R. C. Young	84.85		
Edith	37.01	7	6	Sarah Dixon	278.84		
Egalite	82.38			Sakana	3.84		
Electric	16.51			State of California	1,260.06	20	
Elwood	420.54			Stark St. Ferry	174.75	2	10
Emma Hayward	456.57			Stark St. Ferry No. 7	299.36	2	
Enterprise	137.41			S. G. Reed	607.26	8	
Escort No. 2	72.92	12		Salem	240.08	1	8
F. P. Wright	7.93			Salem No. 3	36.00	1	6
Fannie	276.41	5		Sea Foam	4.95		
Fisher	32.09	5		T. J. Potter	589.60	9	
Geo. H. Chance	71.17			Tacoma	1,311.81		
G. W. Shaver	276.15	2	4	Toiwa	6.27		
General Canby	44.48	9		Telephone	443.24	4	
Governor Newell	134.43	1	6	Three Sisters	327.33	1	1
Harvest Moon	56.15	1	6	Toledo	206.72	1	5
Harvest Queen	697.04	6		Tonquin	18.61	5	6
Hustler	129.58	2	9	Undine	280.48	3	
Ione	213.40	2		Victorian	809.17		
Ilwaco	62.03			W. H. Harrison	52.86		
Iralda	36.84			Wenona	34.67		
John West	7.68	5		Western Queen	74.72		
J. Ordway	194.74	4		Willamette Chief	523.92	6	
James B. Stephens	26.40	5	4	Willapa	249.52		
Joseph Kellog	272.12	2	2	Willowa	92.05		
La Camas	9.66			Wm. M. Hoag	431.13	1	6
Louisa Vaugn	21.64	6		Wilmington	752.07		
Lena	23.72		10	Young America	42.10		
Lurline	338.38	6					

U U 4.

IMPROVEMENT OF WILLAMETTE RIVER ABOVE PORTLAND, OREGON.

The project for this improvement was adopted in 1878. It consists in snagging operations, bar scraping, contraction of water over shoals, and rock removal, with the object of giving easy navigation for light-draft boats from Portland to Eugene City, Oregon, a distance of 172 miles. The mouth of the Yamhill River, 40 miles above Portland, was the head of an inconvenient low-water navigation in a draft of 2½ feet; only 1 foot could be carried above.

During the low water of last season boats drawing 18 inches of water could ascend as far as Corvallis.

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The total amount appropriated for this work to the end of the fiscal year since the present project was adopted is $124,000. At the commencement of the present fiscal year there was a balance on hand of $6,464.42.

Work done during the season.—The work done during the season consisted of snagging operations, covering the river from Portland to Ingram Bend, 2 miles below Harrisburg, a distance of 150 miles, and in concentrating the water over shoal places by closing chutes and building wing dams. This work was done by the crew of the United States snag boat *Corvallis*. The boat was outfitted early in July with the usual snagging and bar-scraping appliances for shallow streams. In addition it was provided with a moveable set of gins and a hammer for pile-driving purposes. It left Portland on the 6th of July in charge of Capt. George Raabe, who for many years has been engaged in navigation upon this river and is thoroughly conversant with all its difficulties, and knew well where work with the limited funds available could be done to the best advantage.

The boat proceeded up the river as far as the stage of water would permit, removing only the most troublesome snags. Arriving at the upper end of the course near Harrisburg July 20, it then dropped back, making a more thorough cleaning out of the snags. The remainder of the month and the first week in August were occupied with snagging work above Corvallis. A good channel was cleaned out in this reach which will extend the period of navigation here fully a month.

The remainder of the season, which closed September 20, was spent in operations below Corvallis. In the vicinity of Weston there were several places particularly troublesome at low-water stages; these were improved by building low dams made by driving short piles into the sand to a depth of 5 or 6 feet at intervals of from 6 to 10 feet and placing against these small logs and brush weighted down with gravel, rock, or whatever heavy material might be near at hand. At Christman Bar a wing dam of this character was built 500 feet in length; also one at Brentano Slough 215 feet in length; also one at Candiani Bar 225 feet long. The result of these was to concentrate the water and give immediate relief in this part of the river.

During the season there were 577 snags removed.

The work done by Capt. Raabe seemed to give satisfaction to those engaged with him in the navigation of the river. It resulted in giving 2½ feet at low water as high up as Salem, and extending the period for navigation above that point fully a month. This work, however, is but temporary, and in the nature of things much of it may have to be done over again.

The whole of the funds available for work under this appropriation was not expended at this time, when it might have been to good advantage to the upper portion of the river. A small proportion was held in reserve to relieve any urgent necessity that might arise upon the river below Oregon City.

Estimate for the fiscal year ending June 30, 1894.—If these wing dams and dams at the heads of chutes which are put in to serve the purpose of temporary emergencies during low water could be made stronger and more permanent so as to resist the high-water flow, more satisfactory progress could be made in the improvement of this river. In order to provide for the immediate and urgent needs of navigation during low water, the small amounts usually appropriated must be spent in the manner described in temporary work at many places. An appropriation of $60,000 in one sum would permit this to be made permanent, and after that yearly appropriations of from $10,000 to $12,000

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would keep the river in reasonably good boating condition during the low-water season.

The amount of commerce on the river and the economical prosecution of the work to be done seem to justify an appropriation of at least $60,000 for the fiscal year ending June 30, 1894.

APPROPRIATIONS.

Act of—		Act of—	
March 3, 1871	$16,000	March 3, 1881	$15,000
March 3, 1873	3,000	August 2, 1882	5,000
June 23, 1874	7,500	July 5, 1884	10,000
March 3, 1875	25,000	August 5, 1886	10,000
August 14, 1876	20,000	August 11, 1888	29,000
August 18, 1878	20,000	September 19, 1890	11,000
March 3, 1879	12,000		
June 14, 1880	12,000	Total	195,500

Money statement.

July 1, 1891, balance unexpended	$6,464.42
June 30, 1892, amount expended during fiscal year	3,350.49
July 1, 1892, balance unexpended	3,113.93
Amount appropriated by act approved July 13, 1892	*30,000.00
Amount available for fiscal year ending June 30, 1893	33,113.93
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	60,000.00

COMMERCIAL STATISTICS.

This river is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

Statement of Upper Willamette River traffic for year ending June 30, 1892.

The following figures are furnished by the transportation companies doing business on the river.

	Tons.
Passengers (111,566)	8,367
Grain	14,894
Lumber	818
Live stock	314
Coal	251
Wool	368
General merchandise	45,860
Total	70,872

U U 5.

IMPROVEMENT OF COWLITZ RIVER, WASHINGTON.

The project for the improvement of this river, which was adopted in 1882, contemplates the removal of sand bars, rocks, snags, overhanging trees, and other obstructions in the channel from its mouth to a point about 50 miles above. Work has been done to Toledo, 30 miles above the mouth. The ruling depth at low water prior to this was 14 inches. It is now 30 inches when the low water can be kept concentrated on one or two troublesome bars. The original estimate was $5,000 for the first year and an annual expenditure thereafter of $2,000 per year. The total amount that has been appropriated for this work is $19,000.

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*Of which $3,000 is to be used in improving Yamhill River.

The snag boat *Corvallis* was sent into this river September 23, and worked there until the end of October. Her operations extended to Toledo. Fifty snags and sunken stumps were removed from the channel, and a wing dam 400 feet long was built at Toutle River Bar. It extends from the right bank of the Cowlitz obliquely downstream and concentrated the water so as to give a navigable channel at that place. The dam was built of short piles driven into the gravel, with logs and brush held down by gravel and rock. The work was done by the crew of the boat. The work was discontinued on account of a rise in the river. It could not be economically prosecuted at that time.

A crew was shipped for this boat and sent into the river again June 23. The work to be done at this time is the building of wing dams at Keegans Bar about 3 miles below Toledo, for the purpose of increasing the depth of water at that point. At the end of the year, June 30, this work was in progress. This work will exhaust the balance of the appropriation of 1890 that is now available.

The land in the valley of the Cowlitz is extremely productive, and is being cleared up and settled upon rapidly. The farmers above Olequa, the point where the river is crossed by the Northern Pacific Railway are dependent upon poor country roads and the river for getting their produce to market and their return supplies. Any improvement to the river will be of great benefit to these people.

It is estimated that $3,000 can be profitably expended upon the improvement of the navigation of this river in accordance with the project during the fiscal year ending June 30, 1894.

APPROPRIATIONS.

Act of—		Act of—	
June 14, 1880	$2,000	August 11, 1888	$3,000
March 3, 1881	1,000	September 19, 1890	8,000
August 2, 1882	1,000		
July 5, 1884	2,000		19,000
August 5, 1886	2,000		

Money statement.

July 1, 1891, balance unexpended	$3,917.27
June 30, 1892, amount expended during fiscal year	1,901.96
July 1, 1892, balance unexpended	2,015.31
Amount appropriated by act approved July 13, 1892	3,000.00
Amount available for fiscal year ending June 30, 1893	5,015.31
Amount that can be profitably expended in fiscal year ending June 30, 1894. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	3,000.00

COMMERCIAL STATISTICS.

This river is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oregon. The nearest light-house and works of defense are at the mouth of the Columbia River.

Statement of Cowlitz River traffic for the year ending June 30, 1892.

[Furnished by the J. Kellogg Transportation Company.]

	Tons.
General merchandise	11,055
Hay and grain	4,665
Shingles (170,300 bundles)	2,125
Lumber (1,900,000 feet)	2,100
Logs (112,000,000 feet)	195,000
Live stock	2,510
Passengers (25,269)	1,885
Wool	15
Total	219,355

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U U 6.

IMPROVEMENT OF YOUNGS AND KLASKUINE RIVERS, OREGON.

The project for this improvement contemplates the removal of snags, sunken logs, and overhanging trees from Youngs River as far up as the lower end of the cut-off, a distance of 7 miles; and also from the channel of the Klaskuine as far up as Kamms Wharf, a distance of 2 miles. The latter river empties into the former 6 miles above Youngs Bay.

The estimated cost of this improvement was $1,600. The total amount appropriated for the work $1,600. The total amount expended $1,206.79, which has resulted in a channel of 7 feet depth at high tide to the limits named. The balance now available, $393.21, will be sufficient to complete the project. No further appropriation is asked.

Money statement.

July 1, 1891, balance unexpended	$393.21
July 1, 1892, balance unexpended	393.21

U U 7.

GAUGING WATERS OF COLUMBIA RIVER, OREGON AND WASHINGTON.

The object of these gaugings is to ascertain and keep a record of the fluctuations of the Columbia River with the view to gathering information that may be useful in works of improvement on the river, and also by gauges established at various points to indicate to pilots, captains, and others interested in navigation the stage of water on crossings and places of difficult navigation.

A self-registering tide gauge has been in operation at Astoria, Oregon, and one at Cathlamet, Wash., during the entire year.

Daily sheets from the Astoria gauge were exhibited on a bulletin board in that city. These show the stage of water and condition as to roughness on the bar at the mouth of the river and are of great service to commerce.

It is estimated that $1,500 can be profitably expended in this work during the fiscal year ending June 30, 1894.

APPROPRIATIONS.

August 2, 1882	$500
July 5, 1884	1,000
August 5, 1886	1,000
August 11, 1888	2,500

Money statement.

July 1, 1891, balance unexpended	$962.32
July 30, 1892, amount expended during fiscal year	516.00
July 1, 1892, balance unexpended	446.32
Amount that can be profitably expended in fiscal year ending June 30, 1894 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	1,500.00

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U U 8.

[Printed in House Ex. Doc. No. 28, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF WILLAMETTE RIVER, OREGON, FOR IMPROVEMENT OF NAVIGATION AT CLACKAMAS RAPIDS AND ROSS ISLAND AND NEAR CITY OF CORVALLIS.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, November 19, 1890.

GENERAL: To comply with your letter of September 20, 1890, directing me to make preliminary examinations and reports upon certain rivers and bays, provided for in the river and harbor act approved September 19, 1890, with a view to ascertaining whether or not they are worthy of improvement by the General Government, I have the honor to report as follows upon—

Willamette River * * * improvement of navigation at Clackamas Rapids and Ross Island and near city of Corvallis.

The falls of the Willamette are located on that river about 12 miles above the city of Portland, Oregon. Around this immense water power there is gradually being built up large manufacturing establishments and commercial interests. There are also large interests invested along the river between the two places, notably the iron manufacturing establishment at Oswego. There is communication by water between Portland and Oregon City at Willamette Falls. At low water boats drawing more than 3 feet can not ascend to Oregon City, and those drawing more than 6 can not ascend to Oswego. In this portion of the river the two formidable obstructions to greater draft boats are the bars at Ross Island and Clackamas Rapids. The Ross Island bar is near the upper or southern limit of the city of Portland. It is caused by a widening of the river bed in this locality, which disperses the waters, diminishes the flood velocities, and causes a deposition of the heavy material carried along. It will be practicable to improve this bar within reasonable limits of expense to such an extent that vessels drawing 10 feet or more can pass over it at low water. This would be of great assistance to the large interests that are being developed along this reach of the river.

The river and harbor act approved September 19, 1890, appropriates $11,000 for improving Willamette River above Portland, "of which sum $5,000, or so much thereof as may be necessary, may be used, in the discretion of the Secretary of War, for improvement of the river at Clackamas Rapids and Ross Island." In my project for the expenditure of the amount thus appropriated, which was submitted under date of October 6, 1890, and has been returned to me approved, provision was made for a survey of the Willamette River in the vicinity of Ross Island. The field work of this survey has been done, and as soon as the notes can be worked up, plans and estimate of cost of the improvement necessary to be made will be submitted. No allotment from the item appropriated for examinations and surveys will be required for this locality.

Clackamas Rapids is located about 1½ miles below Willamette Falls. At this point the Clackamas River, having a slope of 12 feet to the mile, joins the Willamette with a slope of less than 1 foot per mile. Large quantities of coarse gravel and heavy material are brought down during freshets in the Clackamas and deposited in the Willamette, causing shoal water and a rapid that is very much of an obstruction to navigation. The low-water depth over these rapids does not at present exceed 3 feet. It is practicable to make a considerable increase in this depth which would be very much to the benefit of the commerce of this portion of the river and would be a material aid to the manufacturing interests centered about the Willamette Falls.

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Some additional surveys and investigations will be necessary at this point in order that plans and estimate of cost of the improvement necessary may be made. For this purpose I recommend that an allotment of $400 be made from the funds available for examinations and surveys. The present commerce of the river is about 50,000 tons. As capital is invested at the falls and at other localities along the river below, this commerce will of course increase, and this increase will be greater or less, according as the river is in a more or less navigable condition.

The city of Corvallis is located on the concave bank of a sharp bend in the Willamette River. For some years past the river has been eroding its banks in the bend next above this and has been threatening a cut-off, which if permitted to take place would leave Corvallis some 2 or 3 miles from the river. A portion of this eroded bend has been protected by the General Government at a cost of $12,500. During the high water of the Willamette of last February the Corvallis Board of Trade was greatly alarmed lest this cut-off would then take place, as a large volume of water was escaping through the fields and across the neck of land opposite the city. Some efforts were then made to obtain Congressional action in the matter, but nothing could be done. The revetment so far as it extended protected the bank, but erosion continued above it. It is necessary in the interests of the commerce of the Willamette River that this locality receive further special attention at the hands of the Government. Before deciding what is best to be done a careful survey covering about 5 miles of the river should be made to ascertain what is the extent of the change that has taken place here within recent years and what are the real probabilities of a cut-off. Other data necessary to the formation of plans and estimates for the work required should be collected. For this work there should be allotted $1,000.

The Willamette River at Clackamas Rapids and Ross Island and near the city of Corvallis I believe, for reasons stated herein, to be worthy of improvement by the General Government, and so report, after having made personal examination at these localities.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 21, 1890.

Respectfully forwarded.

The Willamette River at the three points named—Clackamas Rapids, Ross Island, and Corvallis—is considered to be worthy of improvement.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer.

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PROJECT FOR IMPROVEMENT OF WILLAMETTE RIVER AT ROSS ISLAND, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, September 30, 1891.

GENERAL: In compliance with your instructions based upon the requirements of the river and harbor act approved September 19, 1890, I have the honor to submit the following project for the improvement of the Willamette River at Ross Island. This island is located near the southern limit of the city of Portland, where the river suddenly widens from 1,400 feet to 5,200 feet, and then becomes contracted again to 1,600 feet within a distance of about 2 miles. There are here two islands, which divide the river bed into three channel ways, each about 800 feet wide. Across the head of these there is a low flat gravel bar. At extreme low stages all the water discharged by the river passes down the west channel way. At stages above this the other two carry off their proportion of the water, and at extreme high stages the islands are flooded. As a result of these topographical conditions the depth of water available for navigation is not as great in this portion of the river as in the reaches below, and immediately above where 18 feet at low water may be considered as the ruling navigable depth. In the west channel, where all the water is to be found during the low stages, there is a shoal bar which limits the draft of vessels to 7 feet.

In this locality the high water of February, 1890, which is perhaps the highest of authentic record, reached a height of 30 feet above extreme low water. The volume of discharge at low-water stage is approximately 15,000 cubic feet per second. The extreme rise and fall of tide at low water is about 3 feet.

The material composing the river bed in this locality is sand and heavy gravel closely compacted, and offering great resistance to the eroding efforts of the water. In some places cobblestones of considerable size may be found packed in with this material.

It was noticeable that at certain points in this locality a considerable change had recently taken place. Our most recent map covering this reach of the river was constructed from surveys made in the fall of 1886. Before a project for improving the river for navigation could be intelligently studied, a new map from more recent surveys was necessary. These surveys have been made. A tracing from the map constructed accompanies this report.* By comparing this with the previous one, a copy of which was forwarded to the Chief of Engineers with a report under date of December 31, 1888, the changes that have taken place will be noted. The sand and gravel have filled in materially around the heads of the middle and east channel ways, and these have been practically closed to low water. As a consequence of this more water has been passing through the west channel, which is now in a better condition than formerly. Although the material here is hard and compact, there is evidence that a considerable erosion has taken place. By increasing this erosion we may expect eventually to form a very satisfactory channel over this shoal. The ruling depth at low water is now 9 feet.

The deep-draft vessels that now have occasion to go above this shoal draw from 12 to 16 feet. The Willamette River at this point is subject to two annual floods; one, occasioned by backwater from the rise in the Columbia River, may extend from the latter part of May to the end of August. The extreme of this rise has reached 28 feet. The other comes from the rainfall on the watershed of the Willamette, and com-

*Not reprinted; printed in House Ex. Doc. No. 28, Fifty-second Congress, first session.

mences usually about the end of December. The extreme of this flood has reached in this locality 30 feet. Before the river can reach its extreme low stage again, except in case of a sudden freeze up about its head waters, it is subject to backwater from the rise in the Columbia. There is, then, about four months in the year when vessels of the draft mentioned can not go above this shoal.

If a channel having a depth of 14 feet at extreme low water can be provided here, this would doubtless meet all the necessities of the present commerce. The project that I recommend for this is to close the middle and east channel ways or chutes to a height of 4 feet above low water, and throw all the water that now passes down these to that height down the west channel; and to assist the erosion that must follow this by dredging to the extent that will be necessary to form a cut 100 feet wide and 14 feet deep. The material of which this shoal is composed being coarse, compact gravel, the erosion will be slow and the dredging will be more difficult than in the ordinary sand bars. The additional amount of water that it is proposed to throw down this channel will certainly maintain the depth to which we may dredge and cause it to gradually improve. These two chutes convey, practically, no water at the lowest stage in the river. At a 4-foot stage they convey fully one-third of the total discharge, and at higher stages a larger proportion. The mean velocity through the west channel with these chutes closed will be nearly double what it now is at this stage. The dam necessary for closing these chutes will be about 3,000 feet long and located A–B, as shown upon the tracings herewith. The detailed drawings of this and the channel that it is proposed to dredge are also shown upon the same sheet. It is estimated that the dredging to be done here in order to obtain 14 feet at low water will be approximately 26,000 cubic yards.

About 1 mile above the head of Ross Island and in front of the town of Sellwood there is a sand bar over which at low water a ruling depth of 9 feet is found. The material of this is sand, and can be more easily moved than that which forms the obstruction below. A cut about 200 yards in length will be necessary here. To obtain a channel 100 feet wide and 14 feet deep it will be necessary to remove 12,000 cubic yards of sand. It is evident that the river bed at this point is too wide to permit the natural flow of the water to maintain a channel as deep as 14 feet. Dredging will give relief, but to maintain this depth permanently across the bar it may be necessary to build a contracting dike about 400 feet in length from one or the other shore in this locality.

The following estimate of the cost of the work here proposed is submitted.

Ross Island:	
Dam 3,000 feet, at $10	$30,000
Dredging 26,000 cubic yards, at 50 cents	13,000
Sellwood Bar:	
Dredging 1,200 cubic yards, at 25 cents	3,000
Dike 400 feet, at $12	4,800
	50,800
Contingencies	5,100
	55,900

With these improvements completed vessels of the class considered can go up the Willamette River to Jennings Bar, which is 10¾ miles above Morrison Street bridge, Portland. The foot of Clackamas Rap-

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ids is one-half mile above this point and 2¾ miles below the falls of the Willamette at Oregon City.

The most important manufacturing interests that will be benefited by this improvement are located at Oswego, 8 miles above Portland. The yearly tonnage of the material used and the output of the Oregon Iron and Steel Company, located at this place, amounts to 75,000 tons. Whenever the river is in a condition to permit deep-sea vessels to get over the bars that it is in contemplation to improve, a large proportion of the raw material and manufactured products of this concern are transported in such vessels directly to and from the works. When it is not in this condition the expensive process of lightering must be resorted to. If this industry could be fostered to the extent that would result from this improvement there is every reason to believe that it would be greatly increased, to the advantage and development of the country.

The quarries from which rock is at present obtained for the jetty at the mouth of the Columbia River are located near Oswego. It is expected that during the present year between 150,000 and 200,000 tons will be used. This is transported in barges drawing 9 feet when fully loaded. Any improvement of the low-water depths over these shoals will be of great benefit to this work. The commerce that would be benefited by this improvement would seem to warrant that it be made.

Very repectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., October 6, 1891.

Respectfully forwarded to the Chief of Engineers, U. S. A., recommended.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

SURVEY OF WILLAMETTE RIVER AT CLACKAMAS RAPIDS, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, September 30, 1891.

GENERAL: I have the honor to submit the following project and estimate* for the improvement of the Willamette River at Clackamas Rapids, Oregon, required by the provisions of the river and harbor act approved September 19, 1890.

The difficulty in navigating the Willamette River at this point during the lower stages of water is occasioned by the presence of a bar composed of coarse sand and gravel firmly compacted together. These materials are brought down by the Clackamas River, which here empties into the Willamette. During the season of high water in the Willamette the velocity is checked at this point, both by reason of a sudden

* Maps accompanying this report not reprinted; printed in House Ex. Doc. No. 28, Fifty-second Congress, first session.

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increase in the discharge section and the meeting of the current from the Clackamas. This, of course, causes a deposition of the material being carried along by both streams. The Willamette at its lower stages has not sufficient volume or velocity to carry this material farther down. The result is a submerged gravel dam over which boats navigating the river must climb in their passage up the river. The presence of this dam has increased the low-water slope of the river from 3 inches per mile, the average from Portland to the foot of the rapids, to 3 feet and 5 inches per mile, over a distance of about 9,000 feet. The average low-water slope from Portland to Oregon City is 7½ inches per mile. The Clackamas River, coming in nearly at right angles to the Willamette, has a slope of 12½ feet per mile. We have no data concerning the volume of its discharge. At low water it is insignificant, but during the rainy season its volume is considerable, bringing down large quantities of heavy gravel, as the results show. The low-water discharge of the Willamette is about 15,000 cubic feet per second.

In the fall of the year 1851 an attempt was made to improve navigation at this rapid by building a dam from the left bank at the head of the rapid out into the stream so as to force the Willamette water over to the right bank where the Clackamas enters, with the design to establish the channel down that side. This resulted in an entire failure, and low-water navigation terminated at this point until a part of the dam was removed. The dam was made of brush and gravel, and paid for from funds raised by subscription among the citizens of Oregon City. There was already too much dam in the Willamette caused by the débris brought down by the Clackamas. From time to time portions of this old dam, which is now entirely submerged at low water, have been removed. The opening through it is now about 200 feet in width with a depth of 3½ feet at low water. Boats of ordinary power ascend this rapid at all stages of the river. At the extreme low stage considerable trouble is experienced and sometimes the process of lining has to be resorted to.

In consequence of this débris brought in by the Clackamas a pool is found in the Willamette River which extends almost a mile up to the foot of the Willamette Falls. These falls are surmounted by a series of four locks, having a lift of 10 feet each. These locks and the water power of the falls are owned and operated by a corporation existing under the laws of the State of Oregon. The lower miter sill of these locks is located with reference to the low water in the pool so as to give a depth of 3 feet over it at that stage. Were the whole of this gravel bar removed, or even so much of it as would accommodate the low-water discharge of the river on the same slope that it has from Portland to the foot of the rapids, there would result a lowering of the level of this pool at low-water stages which might interfere with the passage of boats into the lower lock. This, however, will not be necessary in order to improve the navigation for all present wants of commerce.

The present low-water channel of the Willamette River through the steepest part of this bar has an average width of about 300 feet with a slope of about 1 on 1,000. Its mean depth is 8 feet, excepting in the section just at the summit of the rapid where the old dam is located. The width here is 500 feet. This channel seems to be all that the low-water flow of the Willamette can maintain against the encroachments of the high-water débris from the Clackamas.

The problem of improvement resolves itself into two distinct parts, one to provide a good low-water channel for the Willamette without affecting the depth of water on the miter sill of the lower lock at Oregon

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City; the other to make such disposition of the Clackamas débris as will prevent it from causing further trouble to navigation through this channel.

If the head of the present channel be improved by removing the remaining portion of the old dam and dredging away sufficient of the gravel in this locality to insure a depth of 8 feet it will be simply extending the present low-water slope farther up stream, but will not affect the condition in the vicinity of the lock. In fact this slope might be diminished one-half without molesting these conditions.

In this locality the ordinary high-water lines of the two banks of the Willamette are about 1,400 feet apart. The left bank is rocky, the right a compact gravel overlaid with soil.

The intervening space is occupied with bars composed of coarse gravel and sand, through which the Clackamas makes its way to the Willamette. These bars are from 2 to 8 feet above the low-water stage, and are now partially covered with a vigorous growth of young willows. During the higher stages of the Clackamas it empties most of its water and débris into the Willamette at the head of the rapids, the two currents being nearly at right angles to each other. If at this time the Clackamas could be turned and made to enter the Willamette farther down in a direction more nearly that of its current, much of its heavier material would be deposited upon these bars, and the balance could be taken care of by the combined waters of the two rivers acting together in the same direction.

To accomplish this turning of the waters of the Clackamas I recommend that a dike be built from the right bank of the Willamette River near its junction with the left bank of the Clackamas, extending across the direction of this latter river and down as far as may be necessary to control the waters over the gravel bar; the lower portion of this dike to be about 400 feet from the low-water line of the left bank of the Willamette. The height of the dike should be at least 10 feet above low water or above that of the highest part of the adjacent gravel bar. It should be built of brush, piles, gravel, and rock. Where the brush will be below low water, as for instance opposite the old dam, it could be used liberally and loaded with rock to prevent erosion. The other portions of the dike would be made of heavy gravel, revetted with rock of sizes that could not be washed away. There is an abundance of material in the immediate vicinity.

In section the dike should be 6 feet across the top with an outer slope of 1 on 2, and an inner slope of 1 on 1. The area of this section will average about 20 square yards. The length of the dike that it is necessary to construct is 6,000 feet.

This brings us to a point where the high water of the two rivers is confined between rocky banks less than 1,000 feet apart. A depth of 42 feet is found here. Immediately below this point, however, the river bed again widens and we find only 5 feet in the channel. This locality is called Jennings Shoal and gives considerable trouble to boats during low water. A large portion of the high water here escapes this shoal by going behind Walings Island. If this water were controlled for a distance of about 800 feet farther it would improve this shoal to the extent of giving at least 8 feet in the channel. For this purpose it is recommended that a stone dike 6 feet high be built from the rocky projection on the left bank, extending down stream 800 feet. The material for this can be obtained in the immediate vicinity.

The aggre gate length of these dikes is 6,800 feet, the cost of building should not exceed $1.50 per cubic yard, or $10 per linear foot.

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The removal of the old dam at the head of the rapids can be effected by charges of dynamite; at the same time the gravel in which it is embedded is loosened and washed away. The cost of this work it is difficult to accurately estimate. It may be approximately given at $3,000. The total estimate of the cost of the improvement in accordance with the project is as follows:

Removal of the old dam	$3,000
Construction of 6,800 feet dike, at $10	68,000
	71,000
Contingencies	7,000
Total	78,000

The traffic to be benefited by this improvement as shown by the information furnished for the year ending June 30, 1891, by the transportation companies doing business on this portion of the Willamette River, was 116,600 tons.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 2, 1891.

Respectfully forwarded.

The object of the construction is to store in the Willamette River bed gravel brought down by the Clackamas, which is a large stream in freshet, with a steep slope. After a period longer or shorter, perhaps a few years, storage room will be exhausted. A preferable plan, if practicable, is to store the gravel before it reaches the Willamette. It does not appear that an examination showing whether or not this system is practicable has been made. It ought to be made before the project is carried out. An examination may require modification of the project. Subject to this consideration the project is recommended.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer.

SURVEY OF WILLAMETTE RIVER NEAR CORVALLIS, OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 30, 1891.

GENERAL: The river and harbor act approved September 19, 1890, provides that an examination and survey be made with the view to improving the navigation of the Willamette River, near the city of Corvallis, Oregon, and also that an estimate of the cost of the necessary improvement be submitted. This duty having been assigned to me by your letter of October 21, 1890, I now have the honor to submit the following report* thereon:

* Map accompanying this report not printed.

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The reach of river deemed necessary to be surveyed in order to arrive at a proper conclusion as to what should be done in this case extends from a point 2 miles below Corvallis to a point 5½ miles above, measured in a straight line. By the meanderings of the present steamboat channel the distance between these extreme points is 13 miles. The average low-water slope throughout this reach is 2.44 feet per mile. The slope at high water is 2.36 feet per mile. Throughout a portion of the distance above Corvallis the low-water discharge is divided between three channels, and during extreme high water the whole valley, with the exception of a few isolated patches, is overflowed. The least distance between banks not overflowed within the limits of the survey is 2½ miles. The high bank opposite Corvallis is 6 miles distant. The bottom is cut up with sloughs, high-water channels, and old river beds, that serve as outlets for the water at medium and ordinary high-water stages. A portion of the bottom is covered with a thick growth of timber and underbrush, and another large portion on a little higher level has been cleared and is under cultivation. The soil here is rich and brings forth abundant crops when they can escape overflow. These lands are subject to overflow at stages ranging from 12 to 20 feet above the low-water stage of the river. The extreme high water of February, 1890, reached 29 feet.

Before these bottom lands were cleared and placed under cultivation the heavy timber and underbrush with which they were covered retarded the water during the periods of their overflow and prevented the washing away of the soil. At the medium and low stages of the river, when it was confined between its banks, the erosion of these banks was limited, on account of the hard nature of the substratum on which the soil rests. This in general is compact gravel or a mixture of clay and sand, offering considerable resistance to the erosive action of the water. At places the soil or sand more loosely formed will extend below low water. When the land is cleared off and the soil loosened up by cultivation the high-water currents have a more marked effect upon the top layer of soil. The damage is greater and more noticeable as the country becomes more settled and more of the ground is brought under cultivation. This land is not overflowed every year; sometimes a period of six or eight years may elapse without a serious flood. Its exceeding great productiveness induces the farmer to take these chances.

In the reach of 3½ miles from Corvallis upstream the river makes a well-defined S. In the upper curve of this S it has been slowly eroding its bank, making the curve deeper. Plotting the original meander notes made in 1852, obtained from the surveyor-general's office, on our recent map, it appears that the apex of the concave bank has advanced 775 feet, or at the average rate of 20 feet per year. The land that has been washed away amounts to 54 acres. The value of this at present prices should not exceed $2,000.

In this locality we find several low places in the land, through which high water escapes across the neck into the river below. Some alarm has been felt lest the whole body of the river might break through here and leave Corvallis some 4,000 feet from the navigable channel of the river. The river and harbor act of 1888 authorized the expenditure of $14,000 in revetting this bend to prevent the threatened change of channel. The bank was graded down to a slope of 1 on 2 and revetted with brush and rock over a width of 18 feet for a distance of 1,676 feet. This effectually protected this portion from further erosion and is still in good condition. In addition to this there was a row of piles 6 feet apart driven on the top of the bank a short distance back from the edge

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with the view to catching drift and checking the velocity of the water when it reached the overflow stage, the idea of this being to assimilate the conditions existing before the trees and underbrush were cut away. The effect of the high water of February, 1890, upon this, and the resulting scouring action of the water in its immediate vicinity, were not such as to warrant the further construction of works of this character. Above the upper end of the revetted portion of the bank there is a hard gravel beach for a distance of about 1,400 feet. This extends back from low water from 50 to 100 feet; then comes the bluff soil bank from 8 to 10 feet high, eroded more or less at high water. In this locality is the head of a low place in the land through which the water flows at ordinary high stages. Above this for a considerable distance the same gravel bed seems to underlie the bluff bank and protect it from erosion except at the higher stages of water. The profile along this low swale shows that the water commences running through it at a 10-foot stage. At that stage the water is 2½ feet above the top of the bank across the lower end of the slough and is backed up to within about 1,700 feet of the point of overflow at the upper end. The fall is then 10 feet. At the low-water stage the surface of the water in the river is on a level with a point 3,500 feet below the head of the swale. This seems to be filled about the head with coarse heavy material brought in during high water. The evidence that this is enlarging or growing deeper is not conclusive.

The total amount expended by the United States in protecting this bend was $12,496.

From a study of the results of this survey and a personal visit to the ground during high water and again at low water, I can not conclude that there is any danger that the channel of the river at low water will pass over this neck within any reasonable time in the future, or that the city of Corvallis will be deprived of its advantage of water transportation. At high stages of the river the water will continue to pass over these bottom lands as it has done in the past, and no amount of money within reason will prevent it.

The present condition of the river in this vicinity as regards navigation may be classed as very good when compared with many other localities along its course where no improvement is contemplated.

In the first bend above Corvallis we find the lower end of a chute that leads across a narrow neck to the river above. The length of this is 3,000 feet. At a 5-foot stage the water commences to run through this chute. The difference of level in the river at this stage between the head and foot of the chute is 8 feet. It is at present very much obstructed with fallen trees and driftwood. If this were cleared out and the trees and underbrush along its banks cut down for some distance back, it would gradually enlarge and serve as an escape during ordinary high stages for a large portion of the water that now passes down around the bend and over the bottom land in front of Corvallis. This fall of 8 feet in a distance of 3,000 feet will give a very swift current through the chute when it is cleared of the obstructions that now encumber it. The sand and gravel at its head may be expected to be washed away and in time the low-water flow of the river may take this course. This will produce a radical change in the regimen of the river in this vicinity and give great relief to the bend below. Navigation during the low-water stages will probably not be so convenient when this takes place as at present, but in time as the head of the slope is washed down it will be less steep and the velocity of the water diminished.

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To the extent of clearing out this chute as indicated above I recommend that work be done in this locality, and estimate the cost of the improvement at $5,000.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 17, 1891.

Respectfully forwarded.

If clearance of the chute A B shall result in a cut-off, the fall through its length of 3,000 feet will be 8 feet, being at the rate of 14 feet per mile, whereas the average fall per mile is about 2½ feet. We must, then, expect development of increased length by erosion of banks working great disturbance of the channel. Indeed, if the new river should not lower its slope by development of length it would become unnavigable at the cut-off.

It is not clear that the advantages to be secured can compensate for the disturbance to result, if the cut-off is to be a result.

It is stated by Major Handbury, in a letter of date subsequent to date of report, that indications point to a shifting of the low-water channel from the middle to the east branch. If this shall occur or if it become certain that clearance of the chute will not make a cut-off, the objections herein named will disappear.

Subject to these qualifications the project is recommended.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer.

U U 9.

PRELIMINARY EXAMINATION AND SURVEY OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS, OREGON, WITH A VIEW OF SECURING 25 FEET AT LOW WATER FROM PORTLAND TO THE MOUTH OF THE COLUMBIA.

[Printed in House Ex. Doc. No. 38, Fifty-second Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 16, 1891.

SIR: I have the honor to submit herewith the accompanying copy of report dated September 8, 1891, by Maj. Thomas H. Handbury, Corps of Engineers, giving results of a survey of the Lower Willamette

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and Columbia rivers, Oregon, with a view of securing 25 feet at low water from Portland to the mouth of the Columbia, made to comply with provisions of the river and harbor act approved September 19, 1890. A copy of his report of October 6, 1890, of the preliminary examination of the locality is also herewith.

Inviting attention to the accompanying reports of October 14, by The Board of Engineers, and of October 5, by the division engineer, Col. G. H. Mendell, Corps of Engineers, on Major Handbury's report, I have to recommend that the project of Major Handbury, as amended by The Board of Engineers, be submitted to Congress as the project for the improvement of the navigation of the Willamette and Columbia rivers between Portland and the Pacific Ocean, required by the act of September 19, 1890.

The project provides for a channel 25 feet deep. The estimated cost is $772,464.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

Hon. REDFIELD PROCTOR,
Secretary of War.

PRELIMINARY EXAMINATION OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS, OREGON, WITH A VIEW OF SECURING 25 FEET AT LOW WATER FROM PORTLAND TO THE MOUTH OF THE COLUMBIA.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 6, 1890.

GENERAL: To comply with your letter of September 20, 1890, directing me to make preliminary examinations and reports upon certain rivers and bays with a view to their improvement, provided for in the river and harbor act approved September 19, 1890, I have the honor to report as follows upon—

The Lower Willamette and Columbia rivers, Oregon, with a view to securing 25 feet at low water from Portland to the mouth of the Columbia.

I am familiar with the portion of these rivers mentioned in this item and can safely say that in my opinion they are worthy of being improved as proposed by the General Government. Portland is the principal city of the northwest and is located on the Willamette River, 12 miles from its entrance to the Columbia and 110 miles from the Pacific Ocean. It is at the head of deep-sea navigation on these rivers and has a large and extensive foreign and domestic commerce. A project for the improvement of this reach of these rivers so as to give an available low-water channel of 20 feet has been in process of execution for some years and it is now about completed. Prior to the commencement of this improvement the ruling depth was 12 feet and at that time the depth of water on the bar at the mouth of the Columbia River was from 18 to 20 feet at low water. By reason of the improvement recently effected on the bar, this depth is now 25 feet, with a fair prospect that it will be 30 feet when the works of improvement are finished. The necessities of the commerce and trade of Portland are such that the deepest-draft vessels passing the bar at the mouth of the Columbia River should be permitted to pass to and from that port without lighterage. A low-water depth of 25 feet throughout this reach of 110 miles

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is a matter of very easy engineering attainment, and I think can be obtained at very reasonable expense.

A study of the problem has already been entered upon under your instructions of January 11, 1890. For the purpose of continuing the surveys and investigations now in progress, I request that I be allotted from the appropriation made by this act for such purpose, the sum of $1,500.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[Second indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., February 10, 1891.

Respectfully returned to the Chief of Engineers.

The Lower Willamette and Columbia rivers are worthy of improvement.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

SURVEY OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS, OREGON, WITH A VIEW OF SECURING 25 FEET AT LOW WATER FROM PORTLAND TO THE MOUTH OF THE COLUMBIA.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, September 8, 1891.

GENERAL: The river and harbor act approved September 19, 1890, directs that a project shall be submitted, with an estimate of the cost for carrying the same into effect, for obtaining a navigable channel in the Lower Willamette and Columbia rivers from the city of Portland to the sea, having a depth of 25 feet at low water. Having completed this duty which was assigned to me by your letter of September 20, 1890, I now have the honor to submit the following report.

The navigable water included in this project extends from the steel railway bridge in the city of Portland to the crest of the bar at the mouth of the Columbia River, a distance of 114 miles, measured along the line of the present ship channel. Of this distance 12 miles are in the Willamette River, the remaining in the Columbia.

There is in this reach an aggregate of 10 miles, over which it will be necessary to deepen the channel more or less before a depth of 25 feet at low water will exist. Four miles of this are in the Willamette River and six in the Columbia. The principal localities in which improvement in the present channel depths seem now to be necessary are in the vicinity of the head of Swan Island; between the lower end of Swan Island and St. John, and Post-Office Bar in the Willamette River; and at St. Helen, Martin Island, Walker Island, Cathlamet Bay, and near Upper Astoria, in the Columbia River.

Before a comprehensive study of the subject of this improvement could be entered upon, it was necessary to make a resurvey of certain portions of each of these rivers. Our latest complete survey of the

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Columbia River, between Cathlamet and Tongue Point, dated back to 1867–'68. In this reach the river is excessively wide, its channels variable, and shoals are numerous. This has been resurveyed, and great changes from the conditions shown by the old charts have been developed. For use in this work and also the establishment of harbor lines for the city of Portland, a carefully prepared map of the Willamette River, from its junction with the Columbia to the south boundary of the city of Portland, has also been made. Maps of the other localities where works of improvement contemplated by this project are necessary, have recently been made in connection with the work in progress under the present project to obtain a channel 20 feet in depth at low water. These, with the other information on the files of this office, give the data necessary for our present purposes.

An examination of these maps reveals the cause of the shoal water in these several localities and at once suggests the general principle on which the plan of improvement should be based. In the Willamette River below Portland, wherever the width at low water is greater than 1,400 feet, the available channel is less than 25 feet in depth; and in the Columbia River as far down as the head of Cathlamet Bay, wherever this width is greater than 4,000 feet, the channel depth is less than 25 feet. Throughout Cathlamet Bay and from its head to the ocean, where an excessive width pertains with numerous sand bars, the ebb and flood of the tide play an important part in determining the location and depths of the channels. To examine the localities minutely where improvements are contemplated, we will commence at the Swan Island obstruction and take them in their order going down. At the railroad bridge, 1⅔ miles above the head of Swan Island, the low-water surface of the river is contracted to a width of 600 feet. At this point the water is so encumbered with wharves and other obstructions that there is practically no increase of width as the river rises. The average low-water depth here is 65½ feet, with a maximum of 80 feet. Below this point the river gradually widens and the depth becomes less. At the distance of 1 mile the width of 1,400 feet is reached, with an average depth of 19 feet and a maximum of 34 feet. One-fourth of a mile farther down the maximum depth of 25 feet is reached, and the low-water width of 1,600 feet, and here is where the first trouble begins. At the head of Swan Island the low-water shores are 3,800 feet apart. The water passes the island in two channels. The south channel is wide and shoal, having scarcely 2 feet at low water. The north, which is the main ship channel, is narrow, but has ample depth after the head of the island is passed. Early surveys show that the south channel had from 5 to 7 feet of water in it. This has gradually shoaled up to its present depths. Its low-water cross section is now 2,600 square feet. It is now practically a high-water chute. The cross section of the north channel at the same stage is 11,140 square feet, or four times as large as the south channel. At a 6-foot stage these sections are about equal, each being 16,000 feet.

The plan adopted in 1877 for the improvement of this part of the river so as to obtain a channel having 20 feet depth provided for closing this south channel or chute to a height of 2 feet above low water, thus forcing all the water flowing in the river to that height down the north channel. The conditions with regard to the amount of money available and the pressing necessities for work at other points have at no time since then until now been such that the funds could be spared for closing this chute. In the meantime a channel having 18 and 19 feet depth has been repeatedly dredged through the bar at the head of

this island only to be filled again to 15 or 16 feet at the next succeeding high water of the Willamette.

To effect the desired improvement at this point it is recommended that the chute on the south side of Swan Island be closed to a height of 4 feet above low water by a dam built along the line which now stands approved for the 20-foot project. This is about 6,800 feet in length, extending from the head of the island upward and joining the left bank of the river. The material in the river bed above the head of this island is coarse, heavy sand and gravel, with some blue clay well compacted together, in which are occasionally found old trees and stumps. The effect of closing this chute will be to diminish the present sectional area at a 4-foot stage about 44 per cent and throw about 43 per cent more water down the north channel. The increased velocity due to this, with the additional contraction of the river that will result from extending wharves out to the new harbor line, will undoubtedly in time open a channel of 25 feet depth. The material in this locality being difficult to move, it may take some years to accomplish this result by the unaided erosive powers of the water. It is advisable, therefore, in order to hasten the results after the dam has been built, to dredge a channel through this bar to a depth of 22 feet, which, it may be expected, it will continually improve until at least 25 feet has been attained. The material to be removed in order to obtain a 22-foot channel 150 feet wide will amount to 125,000 cubic yards. To dredge a 25-foot channel the removal of 236,000 cubic yards will be required. With a channel having a depth of 22 feet at low water and the river contracted to the width at which its natural forces insure 25 feet, it would not seem to be necessary to incur the increased expense of dredging to 25 feet. There is an extreme rise of tide here of 3 feet during the low-water stages of the Willamette, which can be taken advantage of in the event of the arrival of vessels drawing more than 22 feet.

Leaving this locality the next point at which we find an excessive width of river, and with it a less depth than 25 feet, is between the foot of Swan Island and St. John. The width at the foot of the island is now 2,400 feet. The velocity acquired by the water while passing through the north channel is sufficient to maintain a depth of 25 feet for a distance of 2,700 feet below the end of the island. By this time its force has become exhausted by being spread out over the excessive width. The tendency now is toward shoaling at the lower end of the chute behind Swan Island; this will be increased when the upper end is closed to the height of 4 feet. If a dike be built from the right bank commencing about 2,000 feet below the lower end of the island inclining downstream and extending out about 500 feet, thence downstream 3,500 feet, keeping in about 12 feet of water, we keep the water concentrated sufficiently to preserve the 25-foot depth until it reaches the same depth below the bar, the top of this dike to be 4 feet above low water. The amount of excavation necessary to secure a 22-foot channel here is 65,000 cubic yards, and to secure a 25-foot channel, 125,000 yards. A good 25-foot channel is found from this point down until we come to the head of Post-Office Bar, 3 miles below. This bar is caused by an excessive width of river bed and a diversion of a portion of the water down the Willamette Slough. Under the old project a dam was built across the head of this slough leaving an opening of 150 feet for the passage of boats. The top of this dam is 6 feet above low water. Since its construction the water in the Willamette in its immediate vicinity has been shoaling. The

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distance between the 25-foot depths above and below this bar is 11,000 feet.

To effect the desired improvement here I have to recommend that a dike be built perpendicularly from the right bank of the river 1,000 feet long, near the point where the 25-foot depth ceases on the upper side of the bar; a second one 3,000 feet below, 600 feet long, on the same side of the river a little below the head of Willamette Slough; a third one 1,200 feet below, still on the right bank, 400 feet long and inclining downstream, and that a training dike 4,500 feet long be built from the outer end of this downstream practically parallel to the present revetment of the concave bank in this locality and 1,300 feet therefrom. The locations of these are shown upon the tracing herewith. If, after construction, it be found that the distance between the first and second dikes is too great to effect the desired concentration throughout the space, a short intermediate dike can be supplemented. The expense of these will be much less than a long training dike built in 18 feet of water. Being on the convex side of the bend, much more satisfactory results may be expected from them than if otherwise located; these dikes, like the ones previously mentioned, to have a height of 4 feet above low water and to be similarly constructed.

In establishing the degree of contraction necessary to insure the 25-foot depth, I have assumed theoretically that the form of the river bed in cross section to be a segment of a circle having a versed sine equal to the depth required for the channel. Taking the area of the cross-section of the river as I find it I determine the length of the chord for this versed sine when the area of the segment is equal to that of the cross-section. For a 25-foot depth at low water I find that the sections in this locality average about 1,200 feet in width, and for a 29-foot depth at a 4-foot stage the average width is about 1,400 feet. These widths correspond very closely with what would be suggested by an examination of the map where a 25-foot channel is found under normal conditions.

The length of diking required at this bar is 6,600 feet. The amount of material to be excavated in order to obtain a low-water channel 150 feet wide and 22 feet deep is 200,000 cubic yards, and to obtain a 25-foot channel this amount is 375,000 yards.

The foregoing provides for the improvement of the Willamette River to its junction with the Columbia. Proceeding down the Columbia River the first locality that will require especial attention is the bar at St. Helens. Under the present project for obtaining a 20-foot channel a permeable jetty 5,500 feet long has been constructed at this point, having for its object the gradual building up of a sand bar behind it which will concentrate the water in the desired direction and increase its depth in the channel. This is slowly accomplishing its object, but before it can effectually open and maintain a channel having 25 feet depth some additional work will be necessary, looking to shutting off a large portion of the water that now escapes through the dike. This may be accomplished by sinking brush mattresses along the dike and holding these in place with stone. This new work should be brought up to the level of low water. Its cost is estimated at $5 per linear foot, and there is probably 5,000 feet that would require this addition. The amount of material necessary to be excavated here to obtain a 22-foot channel is 12,000 cubic yards; and to obtain the 25-foot channel, 46,000 yards.

Three miles below St. Helens Bar we reach Martin Island Bar. Here the river has a width of 6,000 feet. A portion of the water, estimated to be about one-tenth, was formerly discharged through Burke and

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Martin sloughs on the right. These have been partially closed under the 20-foot project by permeable dams which have effected some improvement in the depth of water over the bar. They will be still further closed under this project. To produce the 25-foot channel, however, it will be necessary to diminish this excessive width at the head of the bar. This may be done by constructing a dike from the left bank out across Deer Island Shoal, this to be about 2,000 feet in length and in height 6 feet above low water. To obtain the 22-foot channel by dredging 40,000 cubic yards of material must be removed, and for the 25-foot channel the removal of 150,000 cubic yards is required.

The next locality where works of improvement are contemplated lies between Mount Coffin and Walker Island. Here the river attains a width of 6,600 feet. There are three channels through this reach, none of which afford a satisfactory depth of water. From Mount Coffin one passes down the right, or Washington shore, to the east of Walker Island, a second passes down the Oregon shore to the west of the island, and the third crosses the head of the island and passes down the east side. This last channel has a ruling depth of only 16 feet. Being wide it carries a large portion of the discharge of the river, particularly during its high stages. The average rise of tide here is about 4 feet. This tidal flow undoubtedly has some weight in determining the depth of water in these channels. The earlier charts of this portion of the river show that the depth in this middle channel was much less than is now found there and greater in the two other channels. If this middle channel be closed and the water passing down either of the others be guided or placed under some sort of constraint to prevent it from spreading over the whole of the intermediate shoal space, one, if not both, of these channels will eventually be improved. The channel on the Washington side seems to be preferred by the pilots and river men generally on account of its directness and the sandy shores which enables them to feel their way through it in dark or foggy weather with less danger than is experienced on the Oregon side where the banks are steep and rocky.

Under the present conditions a 25-foot channel is maintained on this side as far down as Le Du's Landing, 1,600 feet below the extreme point of Mount Coffin. On the opposite side of this channel and a little below Le Du's the shoal is bare at low water. The water that passes through a section of the channel at this point must be what maintains the present depth below until it begins to feel the influence of that which passes through the Middle Channel. By restraining this from spreading out over the shoal and contracting it within the necessary limits it is reasonable to suppose that the 25-foot channel can be prolonged through it. This may be done by constructing a longitudinal dike parallel to the Washington shore and 1,600 feet from it, extending from Mount Coffin down to near the crossing of the Middle Channel, and near where 25-feet depth of channel is again found, thence obliquely across this Middle Channel and thence to the head of Walker Island, as shown upon the tracing herewith. After this dike is built we may naturally expect that deposits will take place on the shoal and the head of the island will be prolonged upwards. The water passing down to the left of the dike will be obstructed in its passage through the Middle Channel and may be expected to improve the channel on the Oregon side. This dike should have a height of 6 feet above low water. The total length will be 13,800 feet. The amount of material to be dredged

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in order to secure a channel having 22 feet depth is 80,000 cubic yards; and to secure 25 feet, 170,000 yards.

Below Walker Island a 25-foot channel may be found until the head of Cathlamet Bay at Jim Crow Point is reached. At this point, which is 29 miles from the crest of the bar, the river commences to widen rapidly, spreading out over numerous shoals separated by channels of varying depths. The width between the mouth of John Day River on the Oregon side and the mouth of Gray River on the Washington side where the widest part is found is 9 miles. Just below this, between Tongue Point and Portuguese Point, it contracts to 4 miles. The main volume of water at Jim Crow Point is divided into two parts, one going down the Washington shore and maintaining the present ship channel along that side for 5 miles farther down, where it crosses over to Tongue Point; the other on being deflected from Jim Crow Point continues in a southwesterly direction, maintaining a 25-foot channel until Snag Island is reached. Here its force is wasted by its being spread out over the adjacent shoals and through smaller channels. Formerly there were two well-defined channels here, one to the north, the other to the south of Snag Island, these joining again below the island. The north channel is now entirely closed, but an opening to the northward is still maintained farther down, through which a large volume of water escapes. At this point the South Channel is shoal. There is a space here of about 3,000 yards length with an average depth of 14 feet, leaving 11 feet to be dredged for a 25-foot channel and 8 feet for the 22-foot channel. After passing this, 25 feet can be carried to a point about 1 mile north of Tongue Point. There is a distance of about 1,000 yards here where dredging may be necessary to give the depth required. At Tongue Point there is a channel leading directly west, having for a short distance at a point near Fort Stevens a least depth of 18 feet, and another passing close around the point and along the shore in front of Astoria. This channel carries greater depths than 25 feet throughout, excepting for a short space just above Upper Astoria. Here the ruling depth is 20 feet.

Following the present ship channel from Jim Crow Point down it inclines south to round the shoal water in the vicinity of Pillar Rock, thence back to the Washington shore, which it follows to the crossing, thence over to Tongue Point. The ruling depth here is practically 20 feet at mean low tide. The average rise of tide is 7 feet.

This channel has the great disadvantage of making a crossing in a wide place in the river bed where the sands are continually working down and changing its direction and capacity. Works erected with the view to holding it in any one position would at times have to contend against the natural inclinations of the river, and would therefore be expensive and uncertain in their results. It would be practicable to force this water to continue down the north shore, and improve the depth of water on that side, should the necessities of commerce warrant the expense. At present the problem is to obtain the depth of 25 feet to the sea by the most practical and economical route, and with the least disturbance of the present existing conditions. Taking the channels in this locality in their different positions as we now find them, and considering the present tendencies of their several courses, together with other facts and interests bearing upon the problem, it would seem best to restore and maintain the one passing to the south of Snag Island. If the water that is diverted by Jim Crow Point into the head of this channel can be continued down and kept from spilling out as it were over the adjacent shoals, and these shoals

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are encouraged to build up, the desired object will undoubtedly be attained. Mention has before been made of the fact that a large portion of this water is lost at Snag Island, where it escapes to the northward. I would recommend that this opening be closed by suitably constructed dikes or dams, and in order to facilitate its passage and give it direction over the shoal below that a channel 22 feet deep and 150 feet wide be dredged through this. The erosive action of the water would continually enlarge this dredged channel until it had gained a normal section commensurate in size with its own requirements. While this is being done there will be a tendency to an increase of flow through the two openings in this locality leading southward into what is known as Prairie Channel. This might cause an enlargement of these, which would retard, if not altogether prevent, the opening of the channel through the shoal. These openings should therefore be closed at the same time that the escape of the water to the northward is prevented. I have indicated on the tracing herewith the location of these dams and of the cut that it is proposed to make through the shoal. The aggregate length of the diking at present necessary in this locality is 15,000 feet. The estimated amount of material to be dredged in order to obtain a 22-foot channel here is 400,000 cubic yards, and to obtain a channel 25 feet in depth the removal of 540,000 cubic yards will be necessary.

Where this channel joins the present ship channel about 1 mile north of Tongue Point there is a distance of 1,000 yards where the present depth is less than 25 feet. The indications now are that this is cutting out, and it is possible that before the permanent works proposed can be constructed we may find 25 feet of water here. In its present condition it will require the dredging of 55,000 cubic yards of material to provide a 22-foot channel and 96,000 yards to provide the 25-foot channel.

At the shoal place before mentioned, which is in front of Upper Astoria, there will be 20,000 cubic yards of material to be dredged in order to obtain a 22-foot channel, and 75,000 cubic yards to obtain the 25-foot channel. From here to the sea, a distance of 15 miles, there is a good channel having a depth of 25 feet or more. In this locality the average rise of tide is 7 feet.

It is not deemed necessary or advisable at the present time to locate any permanent works with the view to controlling the water below Tongue Point. When those that are herein proposed for procuring and maintaining the 25-foot channel above this point have produced their effect a resurvey of the river in this locality will indicate the points where permanent works can be placed to the best advantage, if any be found to be necessary, in order to maintain the deep water to the sea.

It may always be expected that in a wide expanse of river such as is found here, where sands are continually drifted about by the waves and current, that points of shoals will occasionally get into the deep channel and may change its course or temporarily impair its depth, to the disadvantage of commerce. To provide for emergencies of this kind one or more good dredging machines should be constantly on hand, with funds for operating them as may be required. This can not be avoided at the present time by permanent works unless at an expense for original construction and maintenance that would far exceed the expense of the occasional dredging.

Everything should be done to encourage the building up of these shoals so that they may be similar to those on the south side of Cathlamet Bay, near Prairie Channel, where we find them at a height nearly

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to that of extreme tide and covered with grass. When this is done the water will be deep and confined to well-defined channels.

We have every reason to believe that at none of the localities where improvement is required will there be anything more formidable to remove from the desired channel than sand, with perhaps an occasional snag or stump buried in it. The undertaking is not formidable in its character nor are there any difficult abstract engineering problems to be solved. It is merely a question of time and money. If the funds necessary for the execution of the project can be supplied as they can be profitably expended the first results will soon be obtained. We are not wanting in examples from experience, which show clearly that if the funds are not so provided the cost will be greatly increased and the time of procuring the desired results will be greatly prolonged. In the meantime the advantages and profits of the improvement are being lost.

On the tracings which are forwarded herewith I have indicated the positions that seem to me to be the most proper in each case considered for the permanent works to occupy. I also transmit a sheet showing the characteristic cross sections of these works as I would recommend that they be built. These works are all of the same general construction differing only in strength and amount of material used per foot depending upon the forces to be resisted at the location where they are placed. They may be briefly described. Drive two parallel rows of piles to a depth of 12 feet into the bottom of the river. The tops of these to be 4 feet above low water, except at Walker Island where they are to be 6 feet. The rows to be from 4 to 6 feet apart, piles in each row 6 feet apart and each pile opposite an interval in the other row. Piles in each row to be fastened together at top with a waling piece bolted to each one, and also by boards at intervals of 8 inches spiked or fastened to them horizontally on inside, extending from top down to 2 feet below low water. Place one layer of 9-inch fascines 15 feet long between the rows of piles, hold down with rock. Place layers of fascines alternately perpendicular and parallel to rows of piles, to any desired thickness depending upon location; sink these with rock and pile rock on top to height necessary on each side; then fill in between rows of piles to top with fascines and weight down with rock. Hold the two rows of piles together by occasional pieces reaching across the interval and spiked to the waling pieces. In some localities a back brace to resist a tendency to overturn may be necessary. By assembling the material in this manner we can in all cases build a structure proportional in strength to the resistance to be overcome, and with the minimum amount of material. The piles serve as a nucleus around which to build and hold the brush and rock in place. Scouring is provided for and repairs are easily made, and additional strength when necessary is easily given.

The cost of these dikes will vary from $5 to $23 per linear foot, depending upon location. A careful estimate has been made for those required in the Willamette and Columbia rivers, separately, based upon the present ruling prices for labor and material and our experience in constructing similar works in this locality.

From the approximate estimate that I have made, it appears that about 400,000 cubic yards of sand will have to be dredged from the channel in the Willamette River and 600,000 from that in the Columbia to secure a 22-foot channel, making 1,000,000 cubic yards in all. The distance that any part of this is to be moved need not in any location exceed 2,000 feet.

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To insure early and successful results and economy in carrying out the project herein proposed, it is advisable that the amount estimated for its completion be made available before it is commenced, and the erection of the permanent structures should in all cases precede the dredging. Should funds be provided in this manner, there is no doubt but a healthy competition could be engendered for doing the dredging and for delivering the material for the permanent structures in place.

My estimate for the cost of this work is as follows, and contemplates contracting works which will ultimately produce by the natural process of erosion a channel 25 feet in depth at low water; but to hasten this result and, by taking advantage of the tides, secure the benefits of this depth, I estimate for dredging to a depth of 22 feet at low water where this may be found to be necessary.

WILLAMETTE RIVER.

It is contemplated that the expense of closing the chute on the south side of Swan Island will be paid from the funds now available for work under the present project for improvement, and that this work will be done this fall and winter.

Dredging Swan Island Bar:	
125,000 cubic yards, at 15 cents	$18,750.00
Between foot of Swan Island and St. John:	
Diking 4,000 feet, at $10	40,000.00
Dredging 65,000 cubic yards, at 15 cents	9,750.00
Post-Office Bar:	
Diking 6,600 feet, at $8.70	57,420.00
Dredging 200,000 cubic yards, at 15 cents	30,000.00
Total	155,920.00

COLUMBIA RIVER.

St. Helen Bar:	
Additional work necessary to present dike, 5,000 feet at $5	25,000.00
Dredging 12,000 cubic yards, at 15 cents	1,800.00
Martin Island Bar:	
Dike, 2,000 feet, at $9	18,000.00
Dredging 40,000 cubic yards, at 15 cents	6,000.00
Walker Island:	
Diking 13,800 feet, at $10	138,000.00
Dredging 80,000 cubic yards, at 15 cents	12,000.00
Snag Island:	
Diking 15,000 feet, at $11	165,000.00
Dredging 400,000 cubic yards, at 15 cents	60,000.00
Dredging at crossing 1 mile above Tongue Point, 60,000 cubic yards, at 15 cents	9,000.00
Dredging in front of Upper Astoria, 20,000 cubic yards, at 15 cents	3,000.00
Total	437,800.00
Total for both rivers	593,720.00
Add 20 per cent for contingencies	118,744.00
Cost of one dredging machine	60,000.00
Total	772,464.00

The demand for an increased depth of water from Portland to the sea has kept pace with the growth of that city and the development of the country tributary to it. Previous to 1866 the ruling depth at low water was from 9 to 12 feet. Vessels loaded deeper than this in order to reach Portland must take every advantage of high tide and high stages of water in the river. The usual mode of procedure was to bring the vessels either to St. Helen or the mouth of the Willamette River, and lighter as much of its cargo as would enable it to get over the shoal water above. The efforts at improvement were directed to

getting a channel to the sea 15 feet depth at low water. This being attained it was followed by a demand for 18 feet and then for 20 feet. During these times the ruling depths over the bar at the mouth of the Columbia River were from 19 to 22 feet at low water. Vessels drawing more than 22 feet were rarely chartered for this port. In consequence of the jetty now in process of construction and nearing completion at the mouth of the Columbia River we have now an actual depth of 27 feet over the bar at low water with every reason to believe that there will be 30 feet before the end of the year. There is no apparent reason why the very deepest-draft vessels may not now be chartered for cargo at the city of Portland. If the channel in the Columbia and Willamette rivers at the points mentioned in this report be not improved to the depth corresponding to the draft of the vessels which will not exceed 25 feet except in cases so rare that they need not be provided for, then the vessel must be lightered at Astoria in proportion as her draft exceeds the depth of the channel. Deep-sea vessels will always attempt to load as far inland as circumstances of profit will permit. Lightering at best is an expensive operation, and in these days of close competition it is desirable in all cases to keep it at a minimum. The demurrage consequent upon this is always a large item of expense. The total lighterage to and from Portland during the year ending June 30, 1891, was 24,300 tons. This is growing less each year as navigation improves. The rate now paid for lighterage is 50 cents per ton. The average draft of the foreign vessels passing out over the bar during the year was 21 feet.

Portland, situated at the head of deep-water navigation, over 100 miles inland, possessing great wealth and assured prosperity, is naturally desirous that all products and commodities coming to her port or exported from it shall have every advantage of cheap transportation. The value of the exports from the Columbia River during the year ending June 30, 1891, was $6,089,585; the imports, $1,325,400. The gross tonnage passed in and out over the bar at the mouth of the river, as reported by the collectors of customs at Portland and Astoria, was 1,923,818 tons. In addition to this deep-sea tonnage there is a local tonnage amounting to 1,154,294 tons, making a showing of over 3,000,000 tons for the Willamette and Columbia rivers between Portland and the sea. The total custom-house receipts for last year were $649,531.83.

The jobbing trade of the city of Portland for 1890 is estimated to be $131,550,000, against $115,000,000 for 1889; an increase of $16,550,000.

More detailed statistical data bearing upon this improvement will be found in my annual reports on the improvement of the mouth of the Columbia River and the improvement of the lower Willamette and Columbia rivers, submitted to the Chief of Engineers for the year ending June 30, 1891.

Accompanying this report there are transmitted the following tracings.* Columbia River from Cathlamet to Tongue Point; Columbia River in vicinity of Walker Island; Columbia River in vicinity of Martin Island; Willamette River from Portland to its junction with the Columbia, two sheets; one sheet showing characteristic sections of proposed dikes.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

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*Not reprinted; printed in House Ex. Doc. No. 38, Fifty-second Congress, first session.

LETTER OF COLONEL G. H. MENDELL, CORPS OF ENGINEERS, DIVISION ENGINEER, PACIFIC DIVISION.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., October 5, 1891.

GENERAL: The following remarks apply to the report and project of Major Handbury for securing a 25-foot low-water channel from Portland to the Pacific Ocean, this day forwarded.

1. THE WILLAMETTE RIVER.

The project for the Willamette River is recommended, with the exception that the two groins proposed for Post-Office Bar ought to be omitted. The constructions ought to be parallel instead of perpendicular to the stream. Experience has fully demonstrated that the general result of groins is injurious.

2. COLUMBIA RIVER.

It is thought that if the existing dike at St. Helens be filled there will be no difficulty in maintaining 25 feet of water at and beyond its extremity. Project recommended.

MARTINS ISLAND BAR.

The distance over which there is less than 25 feet of water is about 4,000 feet. The groin proposed is regarded as inadequate. It is recommended that it be replaced by a dike along the Deer Island Shoal, parallel to the channel. The mean rise of tide at St. Helens is stated on Coast Survey charts to be 18 inches.

WALKERS ISLAND.

The tide here is an important element, the mean rise is 3½ feet. The river is about 6,300 feet wide. Formerly there was a good channel on each bank of the river, separated by middle sands about 2,000 feet wide, and more than 2 miles long. On these sands there was little water—for a half mile 8 feet or less. Now, for about 2 miles the depth is from 8 to 18 feet. There is now no good channel.

To restore the channel it is necessary to restore the shoal for at least 2 miles in length, and a half mile in width if practicable, building it up to low water. As the tide plays a great part here I do not see the necessity of carrying the works higher than 2 or 3 feet above low-tide level.

Inasmuch as the dike does not throughout its length, and in the best way, promote building up the height of the shoal, it is believed that better results would follow if the upper 2,000 or 3,000 feet were omitted, and the estimated cost thereof be applied to low works extending in a southerly direction over the shoal, and arranged to promote deposits.

The lower portion of the dike which closes the channel over the shoal answers a good purpose.

With these modifications the project for Walkers Island is recommended.

CATHLAMET BAY.

In this estuary the mean rise of tide is about 6 feet, and all of the flood waters stored in the rivers above, both Columbia and Willamette, return through this bay to the ocean. In moderate stages the tidal

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component in this part of the river exceeds the fresh-water drainage.

A wide and deep channel in Cathlamet Bay, able to pass the flood without needless retardation, would give a greater rise of tide at all points above, and work improvement in all channels below, including the bar at the entrance. But any channel to be permanent through this wide expanse of sands needs to be maintained by constructions which shall insure a common path for its proportion of the flood and ebb. There have been several channels through this bay, each used for a time, then obstructed beyond the point of convenient navigation, then abandoned for another. There has always been a minimum depth of about 14 to 16 feet somewhere in Cathlamet Bay, which has limited and delayed navigation, no matter where the channel has been. The channel now used is on the north shore, crossing the river to Tongue Point. This has been in use for a number of years. For a long time the channel was in the middle of the bay, varying its position from time to time. The processes by which one channel deteriorates and another is bettered have not been clearly established. It is by no means certain that the sand which obstructs the channel is brought from above, down stream. Nor is it established that the sand is brought from below by the flood tide, although there is good reason to suppose that this is at least partially true. Whatever its direction the movement is in the deepest water. The fact that a portion of a tidal channel lies across the axis of an estuary is, in my judgment, neither a good nor a bad symptom. In selecting a channel for improvement, it is thought that the volume of tidal water as exhibited by the width and depth is a controlling consideration. Another consideration is convenience of navigation. The channel on the north shore is on the whole easier to navigate in dark or thick weather.

Selection of the channel to be improved ought to be made at the time when the works are about to be constructed. In regard to the features of the proposed improvement it may be said that the dredged channel ought, for convenience of navigation, to be straight, and wider than 150 feet. Its curved trace seems to have been adopted to take advantage of a better depth for a short distance. This is not recommended as being really economical.

There seems to be no necessity in these tidal waters to carry construction to a greater height than 2 or 3 feet above low tide.

Subject to these considerations the project, so far as it relates to Cathlamet Bay, is recommended.

LOWER BAY.

Vessels have always passed to and from the ocean below Tongue Point by way of the southern channel which lies in front of Astoria. This channel appears to have deteriorated. It is obstructed in front of Astoria by the Gilman Reef, and by the wreck of the *Sylvia de Grasse* and the rock upon which she struck. These features, together with cross channels leading from the Astoria Channel to the Middle Channel, seem sufficient to account for the dwindling that is apparent from comparisons of channel sections at Smiths Point and others above as far as Tongue Point. Preservation of the capacity of this channel in its former integrity is regarded as an important feature of this system of river improvement. The dredging proposed just north of as well as below Tongue Point are palliatives which may temporarily arrest decay, but it is thought to be insufficient for permanent improvement.

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GENERAL REMARKS.

The whole line of this improvement is in tidal waters. The influence of tide in the 12 miles of the Willamette lying below Portland is, however, so insignificant that we may disregard it. The mean rise at Portland is stated on Coast Survey Charts to be one-half foot. The rise of 3 feet stated in the report is doubtless occasional.

Taking this view of the Willamette River its improvement to the proposed depth may be regarded as independent of the improvement of the Columbia River. It is also regarded as the most difficult part of the whole problem. Its improvement may be undertaken at once, and any changes in the project at points in the Columbia River, whether at Martins Island, Walker Island, or below, can not materially affect the project for the Willamette. Judicious improvement below may increase the influence of the tide at Portland, and thus improve navigation in the Willamette to some extent; but there is nothing in this circumstance which requires a modification of the works projected for the Willamette River.

It is to be observed that while the project is nominally for 25 feet at low stage of river, the estimates are, so far as they relate to dredging, based on a depth of 22 feet, in a narrow channel. It is perhaps true, and indeed it is to be expected, that a narrowed section will be deepened by natural action, yet it may also be said that the best practice is, wherever there are other sections situated so as to be liable to impairment by deposits of scoured material, to make the desired channel by dredging.

The constructions proposed consist of walls of piles: This construction is temporary in character, as the parts alternately wet and dry will have a life of a few years. A better but more costly construction would be to make the work all in stone and brush.

Inasmuch as these improvements are on the lines of a large and growing commerce, it is worth consideration whether the works should not be made permanent once for all.

The estimates, both of values and quantities, submitted by Major Handbury are accepted without revision.

Very respectfully, your obedient servant.

G. H. MENDELL,
Colonel, Corps of Engineers, Division Engineer.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF THE BOARD OF ENGINEERS.

THE BOARD OF ENGINEERS,
New York City, October 14, 1891.

GENERAL: The Board of Engineers, in accordance with your indorsement of October 12, 1891, has considered the project of Maj. Thomas H. Handbury, Corps of Engineers, dated September 8, 1891, for obtaining a navigable channel in the Lower Willamette and Columbia rivers, and the remarks upon the same by Col. G. H. Mendell, the division engineer, and has the honor to submit the following report thereon:

The local engineer and the division engineer differ in reference to the upper two spurs at Post Office Bar on the Willamette River. As

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this is a convex bank, the Board is of opinion that spurs are preferable to parallel works.

In reference to the points of difference at Martins Island Bar the Board is of opinion that the single spur dike proposed is not sufficient. It should be placed about 1,000 feet below the location shown on the tracing, and a longitudinal dike should be constructed from its outer end downstream to give a proper direction to the currents, the length to depend upon the effects while the works are under construction.

At Walkers Island Bar the Board concurs with the division engineer in his proposed modification of the project.

At Cathlamet Bay the Board concurs with the following recommendations by the division engineer:

Selection of the channel to be improved ought to be made at the time when the works are about to be constructed. In regard to the features of the proposed improvement it may be said that the dredged channel ought, for convenience of navigation, to be straight and wider than 150 feet. Its curved trace seems to have been adopted to take advantage of a better depth for a short distance. This is not recommended as being really economical.

There seems to be no necessity in these tidal waters to carry construction to a greater height than 2 or 3 feet above low tide.

Subject to these considerations the project, so far as it relates to Cathlamet Bay, is recommended.

As to making the dikes permanent the Board is of opinion that if sufficient funds are supplied this is, in the end, the most economical.

Respectfully submitted.

HENRY L. ABBOT,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.,
President of the Board.
C. B. COMSTOCK,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.
D. C. HOUSTON,
Colonel of Engineers.
G. L. GILLESPIE,
Lieut. Col. of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

U U 10.

[Printed in House Ex. Doc. No. 36, Fifty-second Congress, first session.]

PRELIMINARY EXAMINATION OF COLUMBIA RIVER, FROM THE MOUTH OF WILLAMETTE RIVER TO THE UPPER LIMITS OF THE CITY OF VANCOUVER, WASHINGTON, WITH A VIEW OF ESTABLISHING A SHIP CHANNEL.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 11, 1890.

GENERAL: To comply with your letter of September 20, 1890, directing me to make preliminary examinations and reports upon certain rivers and bays, provided for in the river and harbor act approved September 19, 1890, with the view to their improvement, I have the honor to report as follows, upon:

Columbia River, from the mouth of the Willamette River to the upper limits of the city of Vancouver, with a view to establishing a ship channel.

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I am familiar with this reach of the Columbia River, having frequently had my attention called to the obstructions therein for the removal of which an estimate is desired. A call for this estimate was made by a resolution of the Senate during its last session, but no funds being available from which the expenses of a survey could be paid, the information desired could not at that time be supplied.

The difficulty to navigation at this point lies in a sand bar located between Vancouver and the mouth of the Willamette River, about 5 miles below. There is but 9 feet on this bar at low water. Were it removed vessels drawing 20 feet or more could easily ascend above Vancouver. The commerce of this city is growing rapidly, and it is not improbable that within a short time it may assume considerable proportions. In fact, with the removal of this bar I see no reason why deep-sea going vessels may not habitually load and unload at the docks of this city. I regard this portion of the Columbia River as being worthy of improvement by the General Government, and therefore recommend that I be authorized to make the necessary surveys and estimate of costs of the improvement proper to be made.

To make this survey and prepare plans and estimate of cost, I estimate that the sum of $1,500 will be required.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

PORTLAND, OREGON, *October 13, 1890.*

Respectfully forwarded, recommended.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer, Pacific Division.

SURVEY OF COLUMBIA RIVER, FROM THE MOUTH OF WILLAMETTE RIVER TO THE UPPER LIMITS OF THE CITY OF VANCOUVER, WASHINGTON, WITH A VIEW OF ESTABLISHING A SHIP CHANNEL.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, October 29, 1891.

GENERAL: The river and harbor act approved September 19, 1890, provides that an examination and survey be made with an estimate of the cost of improvement of the—

Columbia River, from the mouth of the Willamette River to the upper limits of the city of Vancouver, with a view to establishing a ship channel.

This duty having been assigned to me by your letter of October 21, 1890, and being now completed, I have the honor to submit the following report:

The city of Vancouver, Wash., is located upon the right bank of the Columbia River, 103 miles above its mouth, and 5 miles above the mouth of the Willamette River. There is now practically a 20-foot channel

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throughout this distance until a point 2½ miles above the mouth of the Willamette is reached, where the water suddenly shoals to 9 feet. Passing this shoal, which is about 3,600 feet wide at its narrowest part, a channel of 20 feet depth or more is again found and can be carried above the limits of Vancouver. This shoal is evidently caused by the withdrawal from this portion of the river of the large proportion of its water which passes behind Hayden Island. The upper end of this island is opposite Vancouver. It has a length of 4¼ miles and a width of 2,500 feet at its widest part, with an average width of about 1,800 feet. Its top is about 18 feet above low water, and is covered during the high stages. The bottom lands in this vicinity on the Oregon side, and also on the Washington side below Vancouver, are also covered during these stages.

The low-water discharge of the Columbia River at this point is approximately 77,000 cubic feet per second. Of this amount 28,000 cubic feet pass behind Hayden Island, and 49,000 down the main channel. These amounts are the results of rough observations, and may be changed by more carefully collected data. They are sufficiently near correct, however, for the purpose of this report. The extreme high water of 1876 reached a level of 30 feet above the low-water datum. We have no data regarding the quantity discharged at that stage. The area of a low-water section across the head of the slough behind Hayden Island is 25,000 square feet, and that of a section of the main river at its widest place between Vancouver and the mouth of the Willamette is 38,460 square feet. Immediately above the head of the slough the river has a low-water width of 3,400 feet, with a channel 1,000 feet wide and a depth varying from 20 to 30 feet. Where the slough again joins the main river at the foot of Hayden Island we find the same width between banks with two channels, one 800 feet wide with depths over 63 feet, the other 1,000 feet wide, with depths from 20 to 23 feet. The widest distance between banks on the north side of the island where the difficulties to navigation are experienced is 3,200 feet. In this locality there is a sand bar extending out from the right bank and occupying the middle of the river down as far as the foot of Hayden Island. Portions of this are bare at low water, and on other portions the depths vary from zero to 9 and 10 feet. This is evidently caused by the diminution in velocity and volume of water, due to that which passes behind the island during the low and medium stages of the river. The sections above the head of the chute and below the foot of the island show that if the low-water discharge of the chute, which is 36 per cent of the total discharge of the river, can be restored to the main channel, there must necessarily be an improvement in the navigable capacity of this channel. Should the slough be closed to a level with the top of the island, the main channel would eventually be scoured out to a section something like what is found below the foot of the island. There is no necessity for this, however, as the channel depth here is excessive.

As a means of obtaining the necessary depth of water over this obstruction for deep-sea going vessels I recommend that the chute behind Hayden Island be closed by a dam having a height of 4 feet above low water; this dam to be built of piles, brush, and rock; to have a width of 6 feet at the top and a base from 25 to 30 feet in width in the deepest water.

The length of the dam will be 3,000 feet. The banks at the two ends should be protected for a distance of 250 feet against erosion at high

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water; this can be done with a layer of fascines 9 inches thick, covered with rock to a depth of 18 inches.

I estimate that the cost of this work will be approximately as follows, viz:

3,000 feet dam, at $9.33	$28,000
500 feet bank protection, 50 feet wide, at $4	2,000
	30,000
Add 10 per cent for contingencies	3,000
	33,000

This amount should be made available at one time, so that the work when once commenced may be pushed to completion.

I send herewith a tracing* from the map which it was necessary to make in order to properly prepare this project. On this is shown the proposed location of the dam and also a section showing the manner of assembling the material. The piles are to be 6 feet apart and each driven opposite an interval in the other row.

Just where the best water will be in the main channel after the dam has produced its results will be difficult to predict. Examining the map it will be observed that there is a decided tendency for the channel, after leaving the bridge site, to cross over to the north shore of Hayden Island. At the foot of the island this channel shoals up to 5 to 6 feet for a short distance. This shoal will doubtless be washed away. Vessels now going to Vancouver usually keep close along up by the Washington shore. Arriving within about a mile and a half of the town they encounter a shoal place where 9 feet at low water is the most that can be carried for a distance of about 800 yards. The indications are that this is soft material that will be easily eroded. The increase of current and volume of water that will result from the closing of the chute will undoubtedly increase the depth of water in this locality. Whether the best water will be found on this shore or the Hayden Island shore can not now be predicted.

To obtain a temporary 18-foot low-water channel 150 feet wide along this shore by dredging would require the removal of 250,000 cubic yards of material. This at 20 cents per yard would cost $50,000. The same channel can be made by dredging along the Hayden Island shore to the extent of 150,000 cubic yards, which will cost $30,000; a temporary channel, 14 feet deep, can be obtained along this shore by dredging 50,000 cubic yards, at a cost of about $12,500. Any dredging that may be done before the chute is closed will only give a temporary relief, and it may be expected that the next high water of the river will fill up the dredged cut. After the dam has been built and one high water experienced it will be advisable to resurvey the river and note the effect. This will reveal the locality where dredging, if any be necessary, can be done to the best advantage.

The commerce passing this part of the Columbia River during the year ending June 30, 1891, is reported to be: Passengers, 309,412; grain, 1,221 tons; lumber, 2,476,619 feet, B. M.; live stock, 2,930 tons; general merchandise, 30,773 tons. The finishing of the railroad bridge over the Columbia River at Vancouver and the connection of this point with other parts of the country by rail should eventually make it a port of some importance to seagoing vessels. The only obstruction to their

*Not reprinted; printed in House Ex. Doc. No. 36, Fifty-second Congress, first session.

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reaching the place now is the bar just below the town, which it is proposed by this project to remove.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(Through Col. G. H. Mendell, Corps of Engineers, Division Engineer, Pacific Division.)

[First indorsement.]

U. S. ENGINEER OFFICE,
San Francisco, Cal., November 2, 1891.

Respectfully forwarded, recommended.

G. H. MENDELL,
Colonel, Corps of Engineers,
Division Engineer.

U U 11.

ESTABLISHMENT OF HARBOR LINES IN WILLAMETTE RIVER AT PORTLAND, OREGON.

THE CHAMBER OF COMMERCE OF PORTLAND, OREGON,
Portland, Oregon, December 13, 1890.

DEAR SIR: I have the honor to inclose herewith memorial of this chamber, calling your attention to the necessity of establishing harbor lines on both sides of the Willamette River in front of our city. Copies of this same have been sent to our Senators and Representatives and we pray your earnest attention to the subject.

Very respectfully, etc.,

D. D. OLIPHANT,
Secretary.

The Hon. SECRETARY OF WAR.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
December 20, 1892.

Respectfully returned to the Secretary of War.

The chamber of commerce of the city of Portland, Oregon, requests the Secretary of War to establish harbor lines for the harbor of Portland, on both sides of the Willamette River, in front of the cities of Portland, East Portland, and Albina, and as far down the river as St. Johns, under the provisions of section 12 of the river and harbor act approved September 19, 1890.

It is recommended that a Board of Engineers be appointed to consider and report upon the subject of harbor lines at Portland within the limits above designated, the Board to consist of Col. G. H. Mendell, Maj. Thomas H. Handbury, and Capt. Thomas W. Symons, the expenses

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of the Board to be paid from appropriation for "improving lower Willamette and Columbia rivers in front and below Portland, Oregon."

With the approval of the Secretary the order convening the Board will be issued from this office.

Thos. LINCOLN CASEY.
Brig. Gen., Chief of Engineers.

[Third indorsement.]

WAR DEPARTMENT,
December 23, 1890.

Approved as recommended by the Chief of Engineers.
By order of the Assistant Secretary of War:

JOHN TWEEDALE,
Chief Clerk.

MEMORIAL OF PORTLAND, OREGON, CHAMBER OF COMMERCE.

PORTLAND, OREGON, *December 8, 1890.*

The chamber of commerce of the city of Portland desires to invite the attention of the Secretary of War to the fact that it is essential to the preservation of the harbor of Portland that harbor lines be established on both sides of the Willamette River in front of the cities of Portland, East Portland, and Albina, and as far down the river as St. Johns.

It is apparent to the chamber of commerce, and it is hoped that it will also be to the Secretary of War, that the different municipalities bordering on the river should be guided in the establishment of wharves, and that all encroachments upon the river should be restrained by some definite plan fixed by authority above them all; also that a plan for the improvement of the river and the fixation of the channel on the northeasterly side of Swan Island should be definitely determined in the general interest of the harbor and of commerce.

The chamber of commerce of Portland therefore prays that the Secretary of War will, in conformity with the authority granted to him by section 12 of the river and harbor act of September 19, 1890, cause to be fixed the harbor lines of the harbor of Portland within the limits above designated.

The Hon. SECRETARY OF WAR.

REPORT OF BOARD OF ENGINEERS.

PORTLAND, OREGON, *May 23, 1892.*

GENERAL: The Board of Engineer Officers convened by virtue of Special Orders No. 88, dated Headquarters, Corps of Engineers, U. S. Army, Washington, D. C., December 24, 1890, for the purpose of establishing harbor lines for the city of Portland, Oregon, has the honor to submit the following report:

The city of Portland is located upon the Willamette River, about 12 miles above its junction with the Columbia and 110 miles inland from the Pacific Ocean. It is the head of navigation for deep seagoing vessels. The city as at present constituted includes both sides of the Willamette River for a distance of about 4¾ miles. In its southern portion the city limits extend from the west bank only to the middle of the channel for a distance of about 1½ miles north of its southern limit, and in the northern portion these limits extend from the east bank only to the middle of the channel for a distance of about 4⅛ miles south of its northern limit. By this arrangement there is a part of the right bank of the river in the southern portion of the city and a part of the left

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bank in its northern portion that are not at present within its limits. The total length of the river between the extreme northern and southern boundary lines is 10½ miles.

Near the southern boundary the river bed between the main banks is occupied by two islands, Ross Island and East Island, which divide its waters at the higher stages into three channel ways. These islands are overflowed at a stage about 17 feet above low water. At the low stage practically the whole of the water passes down the most westerly channel. A project is now before Congress awaiting appropriation, which proposes to close the middle and east channel way to all water up to a height of 4 feet, by a dam to extend from the right bank across to the head of Ross Island. This work is projected with the view to improving navigation at this point to a depth of 14 feet.

Near the northern portion of the reach the river bed is divided by Swan Island into two channel ways; the westerly one being a high-water chute now closed by a dam across its upper end to all water below a 4-foot stage. The easterly channel way is the one used by deep-sea vessels, and in fact all craft coming to Portland from below. Swan Island is overflowed at a stage about 12 feet above low water. At all other points within the reach under consideration the river flows in a single channel way unobstructed save by the wharves and bridges that have been erected at various points for the accommodation of its commerce and the convenience of traffic across it. The normal width of the river at a bank full stage is about 1,600 feet. At its narrowest point in its original condition the width was 800 feet. By the construction of bridges and wharves natural widths have been very much encroached upon. At its narrowest point, which is the location of the steel railroad bridge, the river is now but 600 feet wide.

It has been a fortunate circumstance for the adjacent property in times of flood that the bottom of the river is susceptible to erosion. What has been lost in available discharge area by wharf encroachments and bridge piers has in general been compensated for by a deepening of the river. In the heart of the city where the greatest encroachments have taken place depths are now found as great as 95 feet. The low-water discharge of the river is approximately 15,000 cubic feet per second. It has been estimated from rough discharge observations taken two days after the highest water reached in February, 1890, which is the highest of which there is any authentic record, that at the extreme of this flood the discharge was approximately 400,000 cubic feet per second. This flood in the Willamette reached at Portland a height of 28.4 feet above low water. The area of cross section at the steel railroad bridge, which is the narrowest point of the river within the limits of Portland, is at low water 37,825 square feet and at extreme high water 55,000 square feet. The original area of cross section at this point was at low water 29,000 square feet and at extreme high water 50,000 square feet. By contracting the width of the river from 800 feet to 600 and putting in the bridge piers scouring has been induced to such an extent that the high-water cross section has actually been increased 5,000 square feet, and the average low-water depth increased 17½ feet.

A map of the Willamette River between the extreme north and south limits of the city of Portland, showing the bridges, streets, wharves, and other features along the banks, has been prepared for the Board. A tracing from this map, with the harbor lines recommended for approval marked in red, is herewith transmitted.* The necessary data

* Omitted.

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for locating these lines are marked upon the tracing, and a description of them accompanies this report.

The Board while locating these lines, which in its judgment seem for the best interest of the commerce of Portland, has kept in view the physical characteristics of the river, and endeavored to avoid as much as possible any interference with structures at present existing along the banks. It is probable that different locations might have been selected for the lines in the narrower portions of the river were it not that the banks in these localities are occupied by structures used for commercial purposes and built at considerable expense to their owners, the removal of which at any time in the future does not now seem to be warranted by the necessities of the case. It is only where wharves extend into the stream abnormally beyond the general line of the other wharves in the vicinity and where there seems to be a material encroachment upon a limited waterway that the Board has thought it necessary to place the harbor lines so as to disturb existing property. In these cases it does not appear that there is an immediate necessity for the removal of the projecting wharves. It is thought, however, that in the interests of the general commerce of the port, they should be set back to the proposed lines when it becomes necessary to repair or renew them. It was found that, with very few exceptions, the line could be located well outside of existing wharves and lines established by city ordinances. The contraction resulting from building structures out to these lines, it is believed, will be beneficial to the harbor.

The chute on the west side of Swan Island has recently been closed by a dam 4 feet high, above low water, with the view to improving the channel over Swan Island Bar. All water up to that stage is forced down the main channel on the east side. The island is overflowed at the ordinary high-water stages. To provide ample waterway in the main channel up to the bank full stage, which is about 12 feet, it is deemed necessary to place the lines on the east side of the island close into the bank, and even, as is shown in two places, to place it within the bank line. A high-water opening is provided on the west side of the island over the top of the dam having a width of 600 feet. The Board deem it essential to the safety of the property bordering on the main channel, and to the interests of navigation, that the chute be not entirely closed to high water.

A similar provision for high-water flow is made between Ross Island and East Island near the southern limit of the city.

With conditions such as exist in this case the Board does not deem it necessary or even advisable to prescribe a bulkhead line separate and distinct from a pier-head line. On the lines proposed the two are considered as coincident. It is recommended that no solid material, or piers or piles, be permitted to be placed beyond these lines on the channel side.

During the deliberations upon this subject the Board held two meetings in the rooms of the Chamber of Commerce of the city of Portland, to which those interested in the subject were invited by public notice given by the daily papers of the city. At the first of these meetings, held August 25, 1891, no one appeared. The second meeting, which was called at the instance of the Hon. M. C. George, chairman of the committee authorized by the legislature of the State of Oregon at its last session to construct free bridges across the Willamette River in the city of Portland, took place March 29, 1892. At that time the lines had been thoroughly studied by the Board, and were marked upon the map, which was exhibited at the meeting. This meeting was largely attended by

influential citizens owning property bordering upon the river and interested in the commerce of the city.

The argument of Mr. George on this occasion was to the effect that, inasmuch as public convenience seemed to demand that free bridges be constructed across the Willamette River in the city of Portland for the purpose of easy communication from one portion of the city to the other, and that these bridges to a certain extent would obstruct free navigation on the river, and their piers and abutments would necessarily occupy a considerable percentage of the cross section available for the flow of the water at these narrow places, which circumstances might tend to increase the overflow on the adjacent property during freshets, the harbor lines should be placed well back upon the adjacent wharves, and it should be required that these, being private interests, should be eventually removed, in order that the evil effects anticipated from the obstruction which the proposed bridge piers will offer to the flow of the water may be made as small as possible. This idea is embodied in a series of resolutions passed by the committee of which he is chairman, and presented to the Board. A copy of these resolutions accompany this report.

At this meeting Mr. R. Koehler, manager Southern Pacific Company, in Oregon, called attention to the fact that the proposed lines as they are located between the steel bridge and East Ankeny street in East Portland would subject his company to serious loss of property and materially interfere with the shipping business transacted at its wharf just above the east end of the steel bridge. Mr. Koehler's views are set forth in a written communication to the Board, copy of which accompanies this report.

Communications were received by the Board from Mr. J. E. Haseltine, owner of the property situated between East Pine and East Oak streets, on the east side of the river, which is crossed by the proposed harbor line; and also from Mr. C. A. Dolph, a part owner and representing the owners of the property directly opposite on the west side, which is crossed by the proposed line. Copies of these communications are herewith inclosed. It is claimed in both these cases that the existing structures do not extend beyond the harbor lines authorized by the city ordinances; that they have been in existence for some years, and were erected at considerable expense to their owners for the accommodation of general shipping business; that to require these to be removed back to the harbor lines proposed by the Board, in order to accommodate shipping at their docks, would necessitate the use of powder to blast away the bottom and bank of the river, which is a hard, compact conglomerate that is not eroded, except with the greatest difficulty, by the action of the water, and that to do this blasting would endanger the stability of the remaining parts of the structure. It is also claimed in all these cases that the projecting portions of the wharves form but a small percentage of what would otherwise be the available area for the flow of the water.

These three cases occur, unfortunately, in the narrowest portions of the river and in the heart of the business portion of the city, where every foot that can be gained which will facilitate the flow of the flood waters is of the utmost importance. In this locality there is already the steel railroad bridge, the piers of which occupy 6½ per cent of the high-water cross section of the river, and plans are now before the Secretary of War for another to cross at Burnside street, about 2,200 feet above this. The piers of this bridge will occupy 9 per cent of the high-water cross section at its locality. Twenty-one hundred feet farther up

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is the Morrison Street Bridge, and 1,400 feet above this is the Madison Street Bridge. In order to a clearer understanding of the situation in this locality the Board has prepared a map on a larger scale, showing these objectionable structures and their relations to harbor lines established by city ordinances and the lines proposed by the Board. On this are plotted sections of the river at the points where these wharves are located. A tracing from this is herewith inclosed.

In the case of the Southern Pacific Wharf it is observed that if its outer line be produced it will intersect the bridge at a point 80 feet outside of the eastern abutment. As the north end of this wharf is within 35 feet of the bridge the result is to practically diminish the width of the waterway at this point 12 per cent and the area of cross section of the river at high water 6 per cent. The wharf line proposed by the Board intersects the axis of the bridge at a point 40 feet inside the outer line of the wharf and 25 feet inside the established city harbor line.

The bank at this point is a hard, compact gravel, very difficult to remove except by blasting, which breaks it up into its small component parts, that are easily washed away. The water being extremely deep immediately in front, it is not probable that dredging to any considerable extent will be necessary in order to get rid of the blasted material.

At the point on the center line, of East Pine street where the proposed harbor line crosses Mr. Haseltine's wharf the shortest distance between the dock lines established by the city on the two sides of the river is 680 feet. The city dock line, with which the outer edge of this wharf coincides, is 60 feet in advance of the proposed harbor lines at the center of East Pine street. By this arrangement the northwest corner of this wharf is set back and its abnormal projection into the river remedied. About 9 per cent is gained in the width of the river and about 3 per cent in the high-water area of cross section.

On the west side of the river and almost immediately opposite the wharf just considered is the third, which projects abnormally into the stream. At this point the river is 740 feet wide between established dock lines. Originally a dock line was established by the city of Portland between Washington and Pine streets, practically upon the line proposed by the Board; subsequently this was moved out to its present position, with which the projecting wharf coincides. At the center of Pine street this extends beyond the proposed line 40 feet. By setting this line back nearly 5½ per cent is gained in the width of the river and 2 per cent in the area of high-water cross section.

Respectfully submitted.

THOS. H. HANDBURY,
Major, Corps of Engineers.
THOMAS W. SYMONS,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
July 16, 1892.

Respectfully submitted to the Secretary of War.

It having been made manifest to the Secretary of War that the establishment of harbor lines is essential to the preservation and protec-

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tion of the harbor at Portland, Oregon, a Board of Engineers was constituted by Special Orders No. 88, Headquarters, Corps of Engineers, December 24, 1890, to consider and report upon this subject; and the within report by the majority of the Board recommends for approval of the Secretary of War the harbor lines described in the inclosed paper and delineated upon the accompanying chart.

It is recommended that the lines selected be approved, and that the Secretary place his approval both upon this report and the tracing submitted.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

WAR DEPARTMENT,
August 9, 1892.

Approved.

L. A. GRANT,
Acting Secretary of War.

DESCRIPTION OF PIER HEAD LINES ALONG THE WILLAMETTE RIVER BETWEEN THE NORTH AND SOUTH BOUNDARY LINES OF THE CITY OF PORTLAND, OREGON, RECOMMENDED FOR ADOPTION AND APPROVAL OF THE SECRETARY OF WAR BY THE BOARD OF ENGINEER OFFICERS CONVENED BY VIRTUE OF SPECIAL ORDERS NO. 88, DATED HEADQUARTERS CORPS OF ENGINEERS, U. S. ARMY, WASHINGTON, D. C., DECEMBER 24, 1890.

The location of the lines, with distances and bearings mentioned in this description, are shown in red ink upon a map on file in the United States Engineer office in Portland, Oregon. A tracing from this was forwarded to the Chief of Engineers, U. S. Army, with report dated May 23, 1892.

Left bank, going north.—Commencing at a point in the center line of Madison street which shall be 300 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Morrison street which shall be 200 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Washington street which shall be 222 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Stark street which shall be 250 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Pine street which shall be 285 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Ash street which shall be 282 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the center line of Ankney (A) street which shall be 245 feet from the intersection of said center line with the center line of Front street measured in an easterly direction; thence to a point which shall be 130 feet north of the center line of Davis (D) street and 212 feet east of the center line of Front street; thence to a point on the center line of Flanders (F) street which shall be 395 feet from the intersection of said center line with the center line of First street, measured in an easterly direction; thence to a point which shall be 110 feet north of the center line of Glisan (G) street and 265 feet east of the center line of First street; thence to a point on the center line of the present steel railway bridge, which shall be 169 feet from the center of the pivot pier, measured in a westerly direction; thence to a point which shall be 380 feet northeasterly from the west side of North Front street, measured on a line which shall be drawn perpendicular to said west side at its intersection with the center line of Johnson (J) street; thence to a point which shall be 340 feet easterly from the westside of North Front street, measured on a line which shall be drawn perpendicular to said west side at its point of intersection with the east side of North Seventh street; thence to a point which shall be 500 feet northeasterly from the west side of North Front street, measured on a line which shall be drawn perpendicular to said west side at its point of intersection with the east side of North Seventeenth street; thence to a point, on the prolongation northward of the center line of Blackstone street, which shall be 1,750 feet from the intersection of said center line

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with the center line of Sherlock Avenue; thence in a direction N. 58° 45′ W., distance 8,070 feet, to a point; thence in a direction N. 44° 30′ W., distance 4,850 feet, to a point; thence, in a direction N. 34° W., distance 2,000 feet, to a point; thence in a direction N. 51° W., distance 2,900 feet, to a point; thence in a direction N. 63° W., distance 3,220 feet, more or less, to a point which shall be on the prolongation southwestward of the center line of Burlington (Washington) street, Saint John; thence N. 51° W., distance 2,430 feet, more or less, to a point which shall be on the prolongation southwestward of the north side of Baltimore (Fanny) street.

Left bank, going south.—Commencing at a point on the center line of Madison street which shall be 300 feet from the intersection of said center line with the center line of Front street, measured in an easterly direction; thence to a point on the prolongation eastward of the center line of Market street which shall be 830 feet from the intersection of said center line with the center line of Front street; thence to a point on the prolongation eastward of the center line of Wood street which shall be 950 feet from the intersection of said center line with the east side of Moody (Willamette) street; thence to a point on the prolongation eastward of the center line of Whiteaker street which shall be 1,000 feet from the intersection of said center line with the east side of Moody (Willamette) street; thence to a point on the prolongation eastward of the center line of Gaines street which shall be 900 feet from the intersection of said center line with the east side of Moody (Willamette) street; thence to a point, on the prolongation eastward of the north side of Lowel avenue (First avenue) which shall be 550 feet from the intersection of said north side with the east side of Moody (Willamette) street; thence in a direction S. 21° W., distance 2,400 feet, to a point; thence S. 1° 30′ E., distance 1,000 feet, to a point; thence S. 12° E., distance 2,800 feet, to a point; thence S. 34° E., distance 1,200 feet, to a point; thence S. 12° W., distance 2,350 feet, more or less, to a point on the prolongation eastward of the north side of Hazel street, said north side of Hazel street being the south boundary line of the city of Portland.

Right bank, going south.—Commencing at a point on the prolongation westward of the center line of East Madison (T) street which shall be 700 feet from the intersection of said center line with the center line of East Water street; thence to a point on the prolongation westward of the center line of East Grant (Adams) street which shall be 400 feet from the intersection of said center line with the center line of East First street; thence to a point on the prolongation westward of the north side of Ellsworth street which shall be 200 feet from the intersection of said north side with the center line of Union avenue; thence in a direction S. 10° 30′ E., distance 3,070 feet, to a point; thence in a direction S. 17° E., distance 1,540 feet, to a point; thence, in a direction S. 18° W., distance 4,000 feet, to a point; thence in a direction S. 9° W., distance 1,800 feet, to a point; thence in a direction S. 12° W., distance 2,290 feet, more or less, to a point on the prolongation eastward of the north side of Hazel street.

Ross Island.—Commencing at a point which shall be 250 feet from the point of intersection on Ross Island of the center line of East First street prolonged with the center line of Gaines street prolonged, measured in a westerly direction along the center line of Gaines street prolonged; thence in a direction S. 15° W., distance 980 feet, to a point; thence in a direction S. 18° 30′ W., distance 1,340 feet, to a point; thence in a direction S. 10° W., distance 1,000 feet, to a point; thence in a direction due south, distance 2,300 feet, to a point; thence in a direction S. 39° E., distance 760 feet to a point; thence in a direction N. 25° E., distance 2,710 feet, to a point; thence in a direction N. 18° E., distance 1,490 feet, to a point; thence in a direction N. 10° 30′ W., distance 3,836 feet, to a point; thence in a direction N. 88° 48′ W., distance 330, feet to a point; thence in a direction S. 7° 24′ W., distance 1,573 feet, to the place of beginning.

Right bank, going north.—Commencing at a point on the prolongation westward of the center line of East Madison (T) street which shall be 700 feet from the intersection of said center line with the center line of East Water street; thence to a point on the prolongation westward of the center line of East Oak (J) street which shall be 260 feet from the intersection of said center line with the center line of East Water street; thence to a point on the prolongation westward of the center line of East Couch (E) street which shall be 230 feet from the intersection of said center line with the center line of East First street; thence to a point on the prolongation westward of the south side of East Glisan (A) street which shall be 340 feet from the intersection of said south side with the center line of East First street; thence to a point on the axis of the steel railway bridge which shall be 450 feet from the center of the pivot pier of said bridge, measured along the axis in an easterly direction; thence to a point on the prolongation westward of the center line of Knight (Mitchell) street which shall be 557 feet from the intersection of said center line with the center line of Loring street; thence to a point on the prolongation westward of the center line of Randolph (Stark) street which shall be 586 feet from the intersection of said center line with the center line of Loring street; thence to a point on the pro-

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longation westward of the center line of Russell street which shall be also on the prolongation southward of outer face of the docks of the North Pacific Terminal Company and 700 feet, more or less, from the intersections of said center line of Russell street with the center line of Loring street; thence along the outer face of said North Pacific Terminal Company Docks, direction N. 39° 45′ W., distance 3,120 feet, to a point; thence in a direction N. 31° 30′ W., distance 2,630 feet, to a point; thence in a direction N. 26° W., distance 2,000 feet, to a point; thence N. 44° W., distance 1,500 feet, to a point; thence in a direction N. 53° W., distance 5,280 feet, to a point; thence in a direction N. 88° 30′ W., distance 400 feet, to a point; thence in a direction S. 69° W., distance 800 feet, to a point; thence in a direction S. 84° 30′ W., distance 500 feet, to a point; thence in a direction N. 66° W., distance 1,100 feet, to a point; thence in a direction N. 51° 30′ W., distance 5,000 feet, to a point; thence to a point on the prolongation southwesterly of the south side of Oneonta (Main) street, in the town of St. John, which shall be 320 feet from the intersection of said south side with the east side of Front street; thence to a point on the prolongation southwesterly of the center line of Burlington (Washington) street which shall be 240 feet from the intersection of said center line with the east side of Front street; thence to a point on the prolongation westward of the north side of Baltimore (Fanny) street which shall be 430 feet from the intersection of the said north side with the east side of Front street.

Swan Island.—Commencing at the point of intersection of the line of the Government dam at the head of Swan Island Chute with a line drawn parallel to Sherlock avenue and 1,560 feet therefrom; thence, in a direction N. 58° 45′ W., distance 5,960 feet, to a point; thence in a direction N. 44° 30′ W., distance 4,650 feet, to a point; thence in a direction due north, distance 360 feet, to a point; thence in a direction S. 68° E., distance 1,750 feet, to a point; thence in a direction N. 80° E., distance 1,500 feet, to a point; thence in a direction S. 61° E., distance 500 feet, to a point; thence in a direction S. 53° E., distance 4,000 feet, to a point; thence in a direction S. 30° E., distance 4,036 feet, to a point; thence in a direction S. 60° W., distance 456 feet, to the point of beginning.

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APPENDIX V V.

SUPERVISION OF THE HARBOR OF NEW YORK.

REPORT OF CAPTAIN FREDERICK RODGERS, U. S. NAVY, SUPERVISOR OF THE HARBOR OF NEW YORK, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

OFFICE OF THE SUPERVISOR
OF THE HARBOR OF NEW YORK,
New York, September 19, 1892.

GENERAL: In accordance with instructions dated August 26, 1892, I have the honor to submit the following annual report:

As this report only covers the period included in the past fiscal year, and as I did not assume charge of this office until July 7, I can only submit a report of the operations of the office as shown by the records thereof.

I have to state that, upon assuming charge of the office, I found three of the four vessels employed under its jurisdiction were not in efficient condition for service, and the fourth one, the tug *Nimrod*, the only really efficient vessel of the lot for general patrol work, had been so continually employed and under steam that she badly needed a general overhauling, in order to preserve her for future service.

I am informed that lack of necessary funds for the purposes prevented the necessary repairs upon these vessels.

I concluded that it was most desirable and a measure of economy to put all these vessels in as efficient condition as practicable for work during the present year, and, with the authority of the office of the Chief of Engineers, the two launches, *Active* and *Alert*, have been thoroughly overhauled and are now in excellent order. The *Argus* is now under repairs and it is proposed to give the *Nimrod* a general overhauling when the services of the former vessel become available.

In reference to the repairs to the *Argus* on this and the last occasion, it was a question whether she was worth the expenditure. It is possible that one more year's service may be got out of her, but I doubt whether it would be expedient to spend any more money on her. However,

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unless repaired and put in a reasonably serviceable condition, but one vessel would be available for patrol work in the lower bay.

I find from the records, that the *Argus* originally cost $21,950, including $700 for plans, and her equipment $1,227.75, making a total cost of $23,177.75. She appears to have been commissioned on November 9, 1889, and since that date the sum of $7,186.12 appears to have been spent in repairs.

I am satisfied from the experience I have had so far, that the recommendation of the supervisor in his report of July 9, 1891, is well founded, viz.:

I have to renew my suggestion in the preceding report, that two more tugs be furnished, one of which will be required to replace the *Argus* before many months, and the other as an auxiliary to relieve broken-down patrolers and perform extra service, which is frequently necessary. It is a well-known fact that no steamboat lines can be handled properly without an extra boat, and the same obtains for the service of this office.

There should be, for an efficient performance of the duties required in patrolling the harbor and adjacent waters, at least three light-draft, but seaworthy, propellers of about 100 feet in length, with fair speed and proper accommodations for the crew to live on board. In addition to the *Nimrod*, two more vessels of about the same size would therefore be required. These vessels would cost $45,000 each, and $12,000 annually for crew and maintenance, including repairs. An appropriation for this purpose, in addition to the usual one of $33,000, is recommended.

The work of the office, and that of those under its jurisdiction, appears to have been efficiently performed.

There has been moved and deposited into and at legally designated places outside the harbor and behind bulkheads in the neighborhood of New York, during the fiscal year ending June 30, 1892, the amount of 10,072,311 cubic yards of material, mud, city refuse, garbage, cellar dirt, ashes, acids, lime, and other matter as per the following recapitulation:

Place of deposit.	Kind of material.	Amount.
		Cubic yds.
Mud buoy	Mud, etc	5,177,174
Refuse Buoy	City refuse, garbage, etc	1,528,237
Scotland Light-ship	Mud, etc	458,252
Long Island Sound	do	790,955
North River	Dirt, ashes, etc., behind bulkheads and on shore for filling.	490,912
East River	do	202,975
Harlem River	do	403,030
Hudson River	do	139,650
Raritan River	do	118,419
New York Bay	do	92,805
Staten Island Sound	do	270,984
Newark Bay	do	237,264
Swinburne Island	do	.....
Pelham Bay	do	.....
Jamaica Bay	do	5,850
Shoal Harbor, New Jersey	do	4,361
Shrewsbury River	do	9,665
Passaic River	do	175,555
Barren Island	Acids, dead animals, etc., on shore in store	56,223
Total		10,072,311

Permits issued 9,273

From the foregoing detailed statement it will be seen that 7,954,618 cubic yards of city refuse, mud, etc., was deposited in the ocean near the mouth of the harbor, and that 2,061,470 cubic yards of cellar dirt,

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ashes, and other inoffensive material was utilized for filling in behind bulkheads, reclaiming land, etc., for which special permits were issued.

The following is a statement to July 1, 1892, of the appropriations made for "prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City":

Appropriation, 1888–'89, act of June 29, 1888		$30,000.00
Expended to July 1, 1890		29,957.09
Balance July 1, 1890		42.91
Appropriation, 1889–'90, act of March 2, 1889		34,070.00
Expended to July 1, 1890		22,315.22
Balance July 1, 1890		11,754.78
Outstanding liabilities, contracts, orders, etc		8,584.04
Balance after deducting liabilities		3,170.74
Appropriation, 1889–'90, act of March 2, 1889, for the purchase or construction of a vessel		60,000.00
Expended to July 1, 1890		36,520.00
Balance July 1, 1890		23,480.00
Appropriation, 1890–'91, act of August 30, 1890:		
For pay of crew and maintenance of steamer *Argus*	$8,000.00	
Expended to July 1, 1891	6,379.08	
		1,620.92
For pay of crew and maintenance of new vessel to be purchased or constructed	10,000.00	
Expended to July 1, 1891	9,621.61	
		378.39
For pay of inspectors and deputy inspector, office force, and expenses of office	15,000.00	
Expended to July 1, 1891	11,785.40	
		3,214.60
		5,213.91
Outstanding liabilities		165.00
Balance July 1, 1891		5,048.91
Appropriation, 1891–'92, act of March 3, 1891:		
For pay of inspectors and deputy inspectors, office force, and expenses of office	$15,000.00	
Expended to July 1, 1892	10,609.52	
		$4,390.48
Outstanding liabilities		2,456.05
Balance July 1, 1892		1,934.43
For pay of crew and maintenance of steamer *Argus*	$8,000.00	
Expended to July 1, 1892	7,093.75	
		906.25
Outstanding liabilities		883.22
Balance July 1, 1892		23.03
For pay of crew and maintenance of steamer *Nimrod*	$10,000.00	
Expended to July 1, 1892	8,646.34	
		1,353.66
Outstanding liabilities		1,312.59
Balance		41.07
Total balance appropriation 1891–'92		2,054.01

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The following is a list of the employés of this office July 1, 1892, with date of their appointment, rating, pay, and station:

Name.	Rating.	Pay.	Appointment.	Station.
John G. Morison	Chief clerk and inspector	1,500	Oct. 21, 1890	Office.
A. C. Murphy	Stenographer	750	Aug. 26, 1889	Do.
Aaron Elliott	Messenger	600	Oct. 3, 1889	Do.
R. C. Hager	Master and deputy inspector	1,200	Nov. 9, 1889	Steamer Argus.
James Quirk	do	1,200	May 1, 1890	Steamer Nimrod.
B. McGovern	Pilot and deputy inspector	600	Feb. 13, 1891	Do.
F. I. Stillwell	do	600	Nov. 1, 1890	Steamer Argus.
G. R. Barker	do	900	July 21, 1890	Launch Active.
William Halliday	do	600	Nov. 9, 1889	Launch Alert.
Fred. A. Tappan	do	900	May 16, 1890	Nimrod's launch.
John B. Folan	Fireman	600	Aug. 31, 1890	Launch Active.
George Murphy	do	720	May 1, 1892	Do.
J. T. Tait	do	900	June 13, 1892	Launch Alert.
John Saunders	do	720	May 19, 1891	Do.
Charles Halliday	Engineer	1,200	Dec. 25, 1891	Steamer Argus.
R. Hammond	Fireman	720	May 17, 1891	Do.
R. Humber	Second deckhand	360	June 1, 1892	Do.
James Bailey	Cook	600	Apr. 27, 1892	Do.
Bernard Kelly	Fireman	720	May 19, 1891	Steamer Nimrod.
W. A. Bloomer	Chief engineer	1,500	May 1, 1890	Do.
Charles Kelly	Fireman's helper	480	May 11, 1892	Do.
F. J. Wren	Carpenter	600	July 1, 1890	Do.
George Wyman	Cook	600	July 9, 1890	Do.

I strongly recommend that two additional tugs be allowed to the force of this office, as suggested in a preceding part of this report.

The following is an estimate of appropriation required for service of the fiscal year ending June 30, 1894, by the supervisor of the harbor of New York:

Detailed objects of expenditure, and explanations.	Estimated amount that will be required for each object.	Amount appropriated for fiscal year ending June 30, 1893.
Prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City:		
For pay of inspectors, deputy inspectors, office force, and expenses of office	$20,000	$15,000
For pay of crew and maintenance of steamer *Nimrod*	10,000	10,000
For pay of crew and maintenance of steamer *Argus*	10,000	8,000
For purchase or construction of two steam tugs	90,000	.....
For pay of crew and maintenance of two steam tugs to be purchased or constructed	24,000	.....
Total	154,000	33,000

Very respectfully, your obedient servant,

FREDERICK RODGERS,
Captain, U. S. Navy, Supervisor.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

CORRESPONDENCE RELATING TO DUMPING OF BALLAST OFF SANDY HOOK.

OFFICE OF THE SUPERVISOR OF THE
HARBOR OF NEW YORK,
New York, December 23, 1891.

GENERAL: I respectfully call to your attention that it is the practice of many of the inward bound freight steamers on entering this port to discharge their ballast outside the bar.

I have lately received a communication from the pilot commissioners on this subject, and they have requested me to define the limits of the

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approaches to the harbor within which the discharge of all ballast shall be regarded as illegal.

I am of opinion that the continual deposit of large quantities of this material near the entrance of the harbor will, in course of time, be a source of danger and inconvenience to navigation. In a case recently reported to me by the pilot commissioners, the British steamer *Hurworth* discharged her ballast outside the bar; and the pilot states that the master informed him that he was ordered by his owners to do so outside the jurisdiction of the United States authorities before entering port. Four hundred tons of stone were thrown overboard from this steamer about 3½ miles from the bar. I think there can be no doubt that the dumping of such large quantities of stone, or any other heavy material generally used for ballast in 7 or 8 fathoms of water should be prohibited.

The British steamer *Elmville* is also reported by one of the inspectors of this office as having discharged her ballast about 5 miles to the southward of Sandy Hook light-ship. From the best information at my disposal, I believe that this practice is almost universal, and that in some instances it is probable that vessels are discharged much within the 3-mile limit.

After consultation with Lieut. Col. Gillespie, United States Engineer Corps, the officer in charge of the improvement of the harbor, I am of the opinion that no deposits of ballast should be permitted within 15 miles of the Sandy Hook light-ship, or in less than 16 fathoms of water, and I request that this limit may be approved as defining the adjacent waters of the harbor.

Very respectfully, your obedient servant,

H. B. ROBESON,
Captain, U. S. Navy, Superrisor.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
December 24, 1891.

Respectfully submitted to the Acting Secretary of War with recommendation for approval.

THOS. LINCOLN CASEY,
Brig. Gen., Chief of Engineers.

WAR DEPARTMENT,
JUDGE-ADVOCATE-GENERAL'S OFFICE,
Washington, D. C. December 29, 1891.

Respectfully returned to the Secretary of War.

Section 6 of the river and harbor act of September 19, 1890 (26 Stat., 453), provides—

That it shall not be lawful to cast, throw, empty, or unlade, or cause, suffer, or procure to be cast, thrown, emptied, or unladen, either from or out of any ship, vessel, lighter, barge, boat, or other craft, or from the shore, pier, wharf, furnace, manufacturing establishments, or mills of any kind whatever, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, slag, cinders, ashes, refuse, or other waste of any kind, into any port, road, roadstead, harbor, haven, navigable river, or navigable waters of the Unted States, which shall tend to impede or obstruct navigation, or to deposit or place, or cause, suffer, or procure to be deposited or placed, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, or other waste in any place or situation on the bank of any navi-

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gable waters where the same shall be liable to be washed into such navigable waters, either by ordinary or high tides, or by storms, or floods, or otherwise, whereby navigation shall or may be impeded or obstructed.

So far as regards the eastern coast of North America it has never been claimed on the part of the United States that its territorial jurisdiction extends beyond 3 miles from low-water mark, except perhaps where the seaward boundary may be drawn from headland to headland. (Wharton's International Law Digest, volume 1, paragraph 32.)

The supervisor of the harbor of New York complains of the dumping of ballast outside the bar at the entrance of the harbor of New York by vessels entering the port, which he says will in the course of time be a source of danger and inconvenience to navigation, and he expresses the opinion that no deposits of ballast should be permitted within 15 miles from the Sandy Hook light-ship, or in less than 16 fathoms of water.

But the territorial authority of the United States does not extend beyond the 3-mile limit. The discharge of ballast inside of that limit is made unlawful by the sixth section of the act of September 19, 1890, and can be prosecuted under the tenth section of that act, but this territorial jurisdiction can not be extended beyond the 3-mile zone. The discharge of ballast at the entrance to the harbor of New York but outside of this zone is evidently an evil which should be prevented, but it can not be reached in the way proposed. It might be effected by international agreements but that would probably be difficult and would in any event take a long time. The most expeditious way of providing a remedy would seem to be by act of Congress, not undertaking to extend the territorial jurisdiction of the United States beyond the 3-mile zone, but subjecting the offending vessel to certain consequences, as for example the right to receive passengers and cargo and clear from the port.

G. NORMAN LIEBER,
Acting Judge-Advocate-General.

WAR DEPARTMENT,
December 31, 1891.

Respectfully referred to the honorable Attorney-General.

Can the supervisor of New York Harbor or the War Department interfere to prevent deposits outside the harbor, as indicated herein, and if so how, and to what extent?

The importance of this subject is the excuse for presenting it to the Attorney-General. These deposits ought to be prevented, and the old idea of a 3-mile limit is, or ought to be, exploded.

L. A. GRANT,
Acting Secretary of War.

[Fourth indorsement.]

WAR DEPARTMENT,
January 6, 1892.

Respectfully returned to the Chief of Engineers, inviting attention to the indorsement of the Acting Judge-Advocate-General and the accompanying letter of the Attorney-General of this date. Let the rule of action be according to the expressed views of the Acting Judge-Advocate-General.

By order of the Acting Secretary of War:

JOHN TWEEDALE,
Chief Clerk.

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LETTER OF THE ATTORNEY-GENERAL.

DEPARTMENT OF JUSTICE,
Washington, D. C., January 6, 1892.

SIR: I have by reference the letter of December 23, written by H. B. Robeson, supervisor of the harbor of New York, to Gen. Casey, Chief of Engineers, with the indorsements, touching the matter of the deposit of ballast outside of New York Harbor, and at a distance of more than 3 miles from the shore, at low-water mark.

You ask my opinion as to whether or not the supervisor of the harbor, or the War Department, can interfere to prevent these deposits.

In answer, I have to say: I know of no statute authorizing such interference, nor of any power to so interfere in the absence of statute. The indorsement of Col. Lieber, Acting Judge-Advocate-General, seems to cover the subject-matter.

Very respectfully,

W. H. H. MILLER,
Attorney-General.

The SECRETARY OF WAR.

PROPOSED DRAFT OF AN ACT TO PREVENT THE DUMPING OF BALLAST OR OTHER BULKY MATERIAL IN THE APPROACHES TO NEW YORK HARBOR AND BAY OFF SANDY HOOK.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any vessel or vessels from which may be dumped or discharged ballast or other bulky material in the approaches to New York Harbor and Bay within fifteen miles of the Sandy Hook light-ship, or in less than sixteen fathoms of water, shall not be allowed by the collectors of customs to receive passengers or cargo, or clear from New York or any port adjacent to New York Harbor and Bay, for the period of six months from the time of the commission of such dumping or discharging of ballast or other bulky material.

SEC. 2. That it shall be the duty of the supervisor of the harbor of New York, appointed and acting under the provisions of an act entitled "An act to prevent obstructive and injurious deposits within the harbor and adjacent waters of New York City, by dumping or otherwise, and to punish and prevent such offenses," approved June twenty-ninth, eighteen hundred and eighty-eight, to detect by proper measures any vessel or vessels which may dump or discharge ballast or other bulky material within the limits specified in the foregoing section of this act, and upon being satisfied of the commission of such act or acts to report the same to the collectors of customs at ports adjacent to New York Harbor and Bay for action by them in pursuance of the provisions in the said foregoing section; and the provisions of the said act approved June twenty-ninth, eighteen hundred and eighty-eight, and the jurisdiction of the said supervisor of the harbor of New York, are hereby extended, so far as they are applicable and consistent with the provisions of this act, to embrace the waters included within the limits specified in section one of this act.

SEC. 3. That the collectors of customs at any or all the ports adjacent to New York Harbor and Bay, upon receipt of information from the said supervisor of the harbor of New York that any vessel or vessels have dumped or discharged ballast or other bulky material within the limits specified in section one of this act, are hereby authorized and directed not to allow said vessel or vessels to receive passengers or cargo or clear from the respective ports within six months from the time of commission of such dumping or discharging of ballast or other bulky material, as provided in section one of this act.

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